



Ca' Foscari  
University  
of Venice

Master's Degree programme

in

Environmental  
Humanities

Final Thesis

# The Role of Botanic Gardens in the Era of the Anthropocene and a Changing Climate

Case Study on the Botanic Garden of  
Bergamo, "Lorenzo Rota"

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**Academic Year**

2022 / 2023

## Acknowledgments

I do not know if it has ever happened to you to experience a burnout. It is likely to occur in this modern accelerated society as diligently explained by Robert Sapolsky in his book *Why Zebra Don't Get Ulcers*, which I recommend reading to anyone like me who faced issues of stress management, anxiety, burnout and light depression. My lowest point in mental and physical health has been around 6 years ago and one of the greatest gifts I could ever receive was a couple of plants, a Peace Lily and a Flamingo Lily. More than the plants per se, what made a difference in my path of recovery was the decision to get to know them. I began studying, reading any book I could find on plant care, as well as trying to enter in emphatic connection with them.

Eventually, they also gave me a precious gift: they helped me slowing down.

I would like to dedicate this thesis to all the plants that contributed to its completion, either in the form of paper for my books and notebooks, or in the form of friends, through which I could always find a way to exit my temporal scale and move to one that suits me better.

I also profoundly thank my Supervisor, Prof. Valentina Bonifacio, and the Assistant Supervisor, Prof. Davide Zanchettin. It has been a pleasure to work and exchange my ideas with you, who have been extremely supportive along my 8 months' slow paced research. In part, it is merit of the combined experiences of all the Professors and fellow students of Environmental Humanities that I can say today to feel more inspired and conscious about the world around us.

A special mention is due to all the staff of the Botanic Garden of Bergamo that welcomed me in their fun industrious family, in particular the director Gabriele Rinaldi, the curator Francesco Zonca, the chief of education Mara Sugni and the administrator Mario Arrigoni.

I cannot forget to thank all my friends, whether distant or close, whether you have been with me since my childhood or you have studied with me, whether you have worked or lived with me, each one of you has contributed to my personal growth and I hope I will never lose your support.

My dear Jonathan, I do not know if tomorrow is the last time I will ever have the occasion to call you my half, but I thank you from the bottom of my heart for being by my side in the past 5 years and always believing in me, especially during times in which I myself could not.

Last but not least, I am grateful for having a loving family, that does not always understand me, but cares about me no matter what. Mother, we may never find a way to get along, but I know we love each other and I hope I can make you proud with my work. Father, there is not a single day that I do not wish you were still with us, yet, luckily, you managed to teach me the most important lesson of all: keep smiling and never give up.

To Titti & Rino

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## Introduction

### *Methodology*

The research project that will be presented here is born from a genuine love and curiosity towards the plant kingdom. In different moments of my past and present, getting to know plants has helped me in getting to know myself as well and it inspired me to find alternative approaches to life, to rediscover the world around me by looking at it through different eyes. For this reason, I thought that there could be no better place to express my potential than a botanic garden, hoping to continue my journey of inspiration in a working environment in direct contact with vegetative entities. When I got the opportunity to actually work within one, through my internship at the Botanic Garden of Bergamo 'Lorenzo Rota', indeed I received new stimuli, but certainly not the ones I was expecting. To my great surprise, I discovered how complex and interdisciplinary these museum entities can be and that their nature is quite distant from the slow paced and quiet life of plants.

Eventually, I realized the great potential botanic gardens have, both in terms of being promoters and testimonial of changes and, due to their interdisciplinarity, I decided that it would be the perfect subject of study for an environmental humanities student like me, who would have the means to explore their facets from multiple points of view.

Yet, it was necessary to establish a clear direction to avoid the risk of going everywhere and nowhere. I opted for merging my personal interests and my academic studies into one. Thus, the question I posed myself is: what is the role of botanic gardens today, in the epoch of the anthropocene and of climate change? Moreover, I could use my direct experience in Bergamo to have a real life example of a botanic garden's approach to modernity.

Since my research was meant to be interdisciplinary, I opted for creating a project within the project, more precisely three meta-projects (one for each chapter). The three chapters will hopefully better represent the complexity of botanic gardens as well as the cohabitation of multiple realities within a unicum, just as the three chapters are part of one thesis. Said chapters are characterized each by a different thematic focus or field: historical, anthropological and climatological. The mixed variety of fields involved, as well as the use of mixed literary resources, field notes, interviews and statistical models, allowed me to carry on a research both bibliographical and experimental.

### *References*

Officially coined in the year 2000 by the chemist Paul Crutzen, the term ‘anthropocene’ was born as a scientific term related to the study of geological time of the Earth to indicate a new epoch following the Holocene (the current epoch officially recognized by the International Commission on Stratigraphy, ICS).<sup>1</sup> The word shares the suffix of other epochs, but it is differentiated by the anthropos, the Greek origin word for human, to allude that human activity has reached the potential to influence so deeply the planet's biotic, geochemical and climatic processes to leave distinct geological traces in sediments.<sup>2</sup>

Although there is criticism over this term since it could be a generalization over the definition of humanity as a unique body,<sup>3</sup> the unequal intentionality of each individual to impact the planet does not exclude that the current changes experienced by the natural processes all over the globe are directly or indirectly caused by human activity or man made objects and waste. For this reason, I agreed on adopting the anthropocene term as a common ground to define the time period we are living in, which we can conventionally position from the mid 20th century onward, as proposed by the Anthropocene Working Group (AWG) in 2019, corresponding to the ‘Great Acceleration’.<sup>4</sup>

Conventions aside, it is noteworthy to point out how interdisciplinary the word actually is and how the anthropocene has entered multiple research fields. In particular, within the anthropological sphere the identification of a main culprit phenomenon within the history of humanity has led to several alternative proposals to it (i.e., plantationocene, capitalocene, chthulucene).<sup>5</sup> The plantationocene is especially interesting within the context of this thesis since it is strictly connected to the evolution of human connection with food through plants, of which there will be a taste in the first Chapter of this work. However, I am very fond of the interpretation given by Donna Haraway, according to which the Anthropocene is more like a boundary event

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<sup>1</sup> Subcommission on Quaternary Stratigraphy. (Last visit 9/06/2023). Working Group on the Anthropocene (AWG). *What is the Anthropocene? - current definition and status*. <http://quaternary.stratigraphy.org/working-groups/anthropocene/>

<sup>2</sup> Joni ADAMSON. 2017. *We Have Never Been Anthropos. From Environmental Justice to Cosmopolitics*, in: Serpil OPPERMANN, Serenella IOVINO. 2017. *Environmental Humanities. Voices from the Anthropocene*. Rowman and Littlefield International. p.160

<sup>3</sup> *ibidem*

<sup>4</sup> Subcommission on Quaternary Stratigraphy. (Last visit 9/06/2023). *What is the Anthropocene?*

<sup>5</sup> D. HARAWAY. 2015. *Anthropocene, capitalocene, plantationocene, chthulucene: Making kin*. *Environmental humanities*, 6(1): 159-165. p.159

than an epoch, a moment of discontinuity that will result in something new, and it is up to us to decide what this new will look like.<sup>6</sup>

After this brief premise on the steps that led me to this research, on the concept of anthropocene and its use adopted in this case, we can now deal with the thesis' structure more in detail.

### *Summary of the Chapters*

As mentioned previously, the thesis is divided in three main chapters, with a focus from the first to the last respectively on the history of botanic gardens, the case study of the Botanic Garden of Bergamo and, finally, the relation between botanic gardens and climate change.

Following the order, the first chapter aims at understanding the innumerable steps that led to the modern conception of botanic gardens and the reasons behind them. It corresponds to an historical overview that touches on several points, mainly the meaning and uses of gardens, which does not intend to be fully comprehensive, but reflects my personal interpretation of the sources available at the time of the draft.

Keeping in consideration the importance given to the historical theme, I preferred to structure the Chapter I in a chronological way: it starts from the first gardens ever recorded in the human history, around 2'000 years B.C., until the birth of botanic gardens in the middle of the 16th century (Section 1.1), followed by the evolution of said institutions through the 17th-19th century, the time of colonialism and imperialism (Section 1.2), which are the premise to the 20th century of modernity (Section 1.3) and, finally, it concludes with a brief discussion over the possibility of a postmodern time for botanic gardens and environmental conservation in the 21st century (Section 1.4).

To condense thousands of years in a few pages might result in a simplification of how history developed; nonetheless, I believe it to be a necessary and useful premise to explore our present with more conscience. In fact, the reconstruction of such complex entities cannot prescind from their context, the interrelation of different practices, values, cultures, religions, economic and political ideas over time. Thus, it became inevitable to begin the historical excursus at the dawn of horticulture, at the beginning of proto-agriculture 10'000 years ago during the Neolithic, when human settlements entered in a more stable cohabitation with plants, the first food crops.<sup>7</sup> This step is important not only due to the intrinsic changes that were enacted both in humans and plants, but also for stressing how horticultural techniques were developed first and foremost for

<sup>6</sup> D. HARAWAY. 2015. *Anthropocene, capitalocene, plantationocene, chthulucene*. p.160

<sup>7</sup> Mark B. TAUGER. 2011. *Agriculture in World History*. Routledge. London and New York. p. 4-5

agricultural reasons. In fact, even after thousands of years and the appearance of gardens whose functions fall outside the scope of food supply, alimentary plants were still protagonists in several cases and there was no clear cut distinction between food plants and ornamental plants.

So we assist to the sprout of gardens in the ancient crescent cultures (i.e. Egyptians, Babylonians, Assyrians, etc...) around the 3rd-2nd millennia B.C. with functions that explore the spiritual connection with divinities and other-worlds as for the Egyptians,<sup>8</sup> or with the expression of the strength of rulers like the Neo-Assyrian Kings.<sup>9</sup> Later on, the Hellenic philosophers will give alternate reinterpretations of foreign approaches to garden-making and consider them as useful tools for rhetoric and governance.<sup>10</sup> Inadvertently, they also insert gardens within the urban texture, especially in connection with education, since philosophers such as Plato, Aristotle and Theophrastus moved part of their Academic meetings in their own gardens (4th century B.C.).<sup>11</sup> This element has been evidently resumed during the Renaissance in Italy, when the birth of botanic gardens was bound to their endless educational purpose by annexing them to Universities.

The perpetuation of past values does not end there. During the Roman empire, (1st century B.C. and the 5th A.D.), the materialistic approach started dominating in the creation of gardens as well and, much like the powerful kings of the ancient past, the Roman aristocracy used gardens to show off their richness and social status.<sup>12</sup> Even if this might not immediately ring a bell, when botanic gardens started flourishing in the European continent during the 16th and 17th century they were also a matter of demonstration of appearance and fame. Whether it was at stake the reputation of a city, a university, a monarch or nobleman, or the combination of all these, botanic gardens were a powerful tool to contribute in raising it and they still convey a political and economic statement today.

Botanic gardens were born also as knowledge centers of accumulation, places where information could be catalogued, studied and maintained orderly. And it does not surprise that the first ones found fertile soil in places where that was already happening, former monastic gardens.<sup>13</sup> Monastic gardens were the most common form of garden during the Middle Ages,

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<sup>8</sup> Kathryn GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. Bloomsbury. p.125

<sup>9</sup> Annette GIESECKE. 2022. *A Cultural History of Plants (Vol.I In Antiquity)*. Bloomsbury Academic. p.158-159

<sup>10</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.129

<sup>11</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.131

<sup>12</sup> Katharine T. VON STACKELBERG. 2009. *The Roman Garden: space, sense and society*. Routledge. p.11

<sup>13</sup> A. VIOLA, M. SPECIALE. 2021. *Andare per Orti Botanici*. Il Mulino. p.9-10

since clerical institutions were keepers of knowledge, in particular medical knowledge that was mainly based on herbal remedies.<sup>14</sup>

The beauty of botanic gardens is that when the first was born in 1544 in Pisa, unconsciously all of these past influences merged into one to form something unique and yet not new: material needs, education, power and fascination, all condensed into the first world recognized botanic garden during the florid Italian Renaissance.

This was the first milestone of the journey into the elaborated history of botanic gardens, but definitely not the last. During the Enlightenment (17th - 18th century) the world expanded, as well as the knowledge and the economies. Along with world explorations, scientific findings and theories that could better explain the more complex reality that the society was witnessing, some countries were able to surf the wave of changes to their benefit.

One of the first nation-state to ever assume such an international role has been the Dutch Republic.<sup>15</sup> And it is of interest for our topic because part of the success of the golden age of the Dutch Republic was connected to the increase in importance of the economic role of botanic gardens. For example, the botanic garden of Amsterdam was turned into an acclimatization and research station of exotic plants to be used for commerce of medical remedies, ornamental plants, foreign goods and delicacies.<sup>16</sup> The Dutch are proud initiators of economic business monopolies of products that are still considered common commercial goods, such as palm oil, coffee and ananas.<sup>17</sup> Less proudly, we could say that in this period the first plantations came to life, in particular coffee plantations in Ceylon (1659) and Java (1696).<sup>18</sup>

After the Dutch, the empire that took over in the global as well as the botanical lead around the end of the 18th century, and that remains in history for its exploitative colonial power, is the British Empire.<sup>19</sup> For over a century the British were the most powerful political entity around

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<sup>14</sup> Michael LESLIE. 2013. *A Cultural History of Gardens in the Medieval Age*. A Cultural History of Gardens: Vol. 2. Bloomsbury. p.2-3

<sup>15</sup> G. ARRIGHI, B. J. SILVER. 2006. *Caos e Governo del Mondo*, (Chaos and Governance in the Modern World System). Bruno Mondadori. p.43

<sup>16</sup> Silvia FOGLIATO. 2021. *Orti delle Meraviglie: i giardini botanici e la diffusione planetaria delle piante*. Derive e Approdi. p.168-169

<sup>17</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.170

<sup>18</sup> Lucile H. BROCKWAY. 1979. *Science and Colonial Expansion: the Role of the British Royal Botanic Gardens*. Studies in Social Discontinuity. Academic Press. p.51

<sup>19</sup> ARRIGHI, SILVER. 2006. *Caos e Governo del Mondo*. p.43



and one of their greatest successes that survived through decolonization and modernity is, indeed, its web of botanic institutions, the Royal Botanic Gardens and its colonial satellites.

The increasing standardization of botanical terminology and taxonomy, thanks to eminent figures like Carl von Linné (1707-1778) and its binomial system, coupled with the determination and initiative of English individuals made it possible to create an empire of botanical knowledge and resources. The most famous of these individuals during the colonial history of the British Empire is with no doubt Joseph Banks (1743-1820), the first manager of the Royal Botanic Gardens of Kew, leader of the Royal Society of London and epistolary correspondent of hundreds and hundreds of people that were its greatest source of information, materials and social power.<sup>20</sup>

He is just one of the many figures that will be mentioned in this thesis and that contributed in transforming the role of botanic gardens through history. Naturally, when it comes to modernity, their role mutated again, adapting to a different context, a society shocked by World Wars, decolonization, globalization, that has defeated the barrier of outer space, but that has to come to terms with environmental exploitation and pollution. Indeed, the 20th century is a century of great changes in values and so it has been for gardens.

Gardens in the colonies that were used as civilizing tools over indigenous cultures, or gardens that were a nostalgic representation of home for colonizers, were often destroyed or simply transformed to lose these political implications and remained as public parks. For instance, this happened for the Kirstenbosch Botanic Gardens in Cape Town, South Africa.<sup>21</sup> In other cases, botanic gardens were a new tool of independence and redefinition of a nation, as for the case of Australia, which invested much resources into valorizing its native flora and indigenous environmental knowledge.<sup>22</sup>

In any case, a key value that spread from the second half of the 20th century onwards is the environmental concerns and the necessity of preservation of natural resources. Luckily for botanic gardens, this was the perfect occasion to put to good use their history of centers of accumulation of botanical knowledge, species and social webs of relations.<sup>23</sup> Thus, similarly to

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<sup>20</sup> D. P. MILLER, P.H. REILL. 1996. *Visions of empire: voyages, botany, and representations of nature*. Cambridge Univ. Press. p.22

<sup>21</sup> J.G. BRAND. 2016. *A Short History of the Company's Garden, Cape Town*. The Heritage Portal. <https://www.theheritageportal.co.za/article/short-history-companys-garden-cape-town>.

<sup>22</sup> Brett M. BENNETT. 2018. *How the colonial past of botanical gardens can be put to good use*. The Conversation. <https://theconversation.com/how-the-colonial-past-of-botanical-gardens-can-be-put-to-good-use-104786>

<sup>23</sup> V. H. HEYWOOD. 2017. *The future of plant conservation and the role of botanic gardens*. *Plant Diversity*, 39(6): 309-313. p.312.

international organizations, botanic gardens became more and more supra-national and transnational entities with a certain amount of decisional weight in international policies for environmental conservation. For example, they contributed in the promotion of a specific Global Strategy for Plant Conservation (GSPC) approved by the Convention on Biological Diversity (CBD) in 2002.<sup>24</sup>

Although plant conservation is a strong dominant aspect of botanic gardens, they still withhold vocational roles that span over education, increasing public awareness and entertainment.<sup>25</sup> And each one of the 1775 officially recognized botanic gardens spread over more than 140 nations<sup>26</sup> has its own unique approach and vision, tailored to its location and purpose.

The second Chapter has the task of demonstrating said diversity of botanic gardens in real life, through an exploration of examples from the Italian context and the detailed case study on the Botanic Garden of Bergamo. In opposition to the Chapter 1, I opted for a less strict structure in this case, free from a chronological order, that would allow for a more immersive experience.

The Section 2.1 is dedicated to a general overview of the sunny peninsula, both regarding its rich natural patrimony and its botanic gardens, which are intimately connected. In fact, the high number of botanic gardens in Italy (over 60)<sup>27</sup> is the natural consequence of an even richer biodiversity. Despite the small extension of territory, the peculiar geomorphology of the country has led to a great diversification of biomes and biological entities: from alpine regions to valleys, from forests to grasslands and coasts, from volcanic zones to wetlands and lakes, there is over 8'100 known species of plants, with a high percentage of endemic species that can only be found in Italy (20%).<sup>28</sup>

In order to promote awareness of the national flora in some cases it has happened that gardens became very specialized depending on their location. For instance, there are several alpine

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<sup>24</sup> Katja Grötzner NEVES. 2020. *Postnormal Conservation*. (SUNY series in Environmental Governance: Local-Regional-Global Interactions). p.25-26

<sup>25</sup> Botanic Garden Conservation International (BGCI). (Last visited 23 November 2022). *Botanic Gardens and Plant Conservation*, <https://www.bgci.org/about/botanic-gardens-and-plant-conservation/>

<sup>26</sup> BGCI. (Last visited 23 November 2022). *Botanic Gardens and Plant Conservation*.

<sup>27</sup> L'Orto Botanico d'Italia. *Elenco degli orti botanici italiani*. (Last visit 13/03/2023). <http://www.ortobotanicoitalia.it/gli-orti-botanici/>

<sup>28</sup> IUCN, Comitato Italiano. 2020. *Lista Rossa della Flora Italiana. 2 Endemiti e altre specie minacciate*. Ministero dell'Ambiente e della Tutela del Territorio e del Mare. p.10

botanic gardens that focus on the flora native to the alpine regions, such as the Paradisia Alpine Garden in Valle D'Aosta, within the Gran Paradiso National Park.<sup>29</sup>

Moreover, as explored in the historical background, Italy holds the primate over the establishment of the first botanic gardens, and the Botanic Garden of Padua is the oldest botanic garden in the world still standing in its original position since 1545.<sup>30</sup> This means that there is also a long tradition of botanical research that dates back to the 16th century and, in some cases, it is still a main value for some gardens, especially those connected to Universities.

No matter their approach, in Italy there is a widespread general struggle for most botanic gardens to receive resources, fundings and effective cooperation with other institutions, which is not necessarily due to a lack of initiative. However, in some cases, a positive attitude driven by creative thinking can make a difference for the success of a botanic garden. And here comes into the picture the Botanic Garden of Bergamo, a leader for its modern approach of flexibility, social interdependency and interactivity.

The core of Chapter 2 is dedicated to the case study of my 6 months internship experience in Bergamo, in which I was able to perform different tasks as well as meeting a great array of people, both part of the permanent staff of the botanic garden as well as temporary employees, volunteers, external freelancers, friends of the institution and visitors of all sorts.

Around the end of my internship, I carried out a series of individual interviews with a dozen of figures involved in the garden management and activities, to obtain a more comprehensive view of the character of this entity. The interviews were as much as possible free of a predetermined structure, because I wanted to leave to each person the space to say anything they felt to share with their own time (even if time is definitely not a spare resource for the permanent staff of the garden).

When it was time to analyze the results of my interviews I could easily recognize some key words out of the conversations I had with different individuals, each with his or her own view, that composed piece by piece a more complete frame of the essence of today's Botanic Garden of Bergamo. The keywords, which were used as thematic directions for my case study, are six: Museo di relazione (relation museum), Educazione esperienziale (experiential education), Alla portata delle persone (at hand), Flessibilità (flexibility), Integrazione (integration), Visione volta al futuro (future oriented vision). To conclude the Chapter, in the Section 2.3 are briefly discussed the main issues and the strong points of this institution.

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<sup>29</sup> Parco Nazionale Gran Paradiso. (Last visit 13/03/2023). Giardino Botanico Paradisia. <https://www.pngp.it/visita-il-parco/giardino-botanico-alpino-paradisia>

<sup>30</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.9-10

Finally, the Chapter 3 also has a tripartite division, but its format is less creative than the previous one due to its scientific thematic focus. My intention is to demonstrate how botanic gardens' interdisciplinarity can be effective in dealing with complex issues such as climate change from multiple sides. In order to do that, first it is necessary to understand what is a climatic change and what it consists of the one we are currently experiencing.

The Section 3.1 addresses these questions and it offers insights over the reciprocal influences between climate and biomes. Moreover, it includes a focus on the possible effects on the Mediterranean area and the Italian peninsula as well, based on the latest updated Intergovernmental Panel on Climate Change (IPCC) reports and national reports (Sistema Nazionale per la Protezione dell'Ambiente, SNPA).

The middle Section delves into the connection between climate change and botanic gardens, what has been done and what can still be done. Actions do not have to be strictly related to the cut in carbon emissions, actually, the greatest potential for gardens is to become inspirational leaders for the society through indirect adaptation actions, as well as through research, education and amplifying public awareness on the topic. The examples are numerous and there are international organizations such as the Botanic Garden Conservation International (BGCI) which contribute in gathering such information and creating guidelines for institutions all over the world. In particular, one relevant document is the BGCI's text *The Role of Botanic Gardens in Practicing and Promoting Environmental Sustainability*,<sup>31</sup> or the one published in 2021, *Botanic Gardens and Climate Change Education*.<sup>32</sup>

The action that caught my interest the most, however, is the innovative Landscape Succession Strategy implemented by the Royal Botanic Garden of Melbourne, in Australia. This strategy was born in 2016 as part of a series of adaptation measures to global warming and water management plans for the gardens, but it soon became a major strategy on its own. It briefly consists in analyzing the current and future vulnerabilities of the living collection based on projected climatic models, and subsequently making changes in order to modify the collection so that the majority of the specimens will be more suited for the future climate at the end of the century.<sup>33</sup>

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<sup>31</sup> BGCI. 2020. *The role of botanic gardens in practicing and promoting environmental sustainability*.

<sup>32</sup> BGCI. 2021. *Botanic Gardens and Climate Change Education*. *Roots*, 18(1): 1-43.

<sup>33</sup> Royal Botanic Gardens Victoria. 2016. *Royal Botanic Gardens Victoria, Landscape Succession Strategy - Melbourne Gardens 2016 - 2036*. Royal Botanic Gardens Board Victoria.

This action, which even led to the creation of a Climate Change Alliance for Botanic Gardens (CCABG)<sup>34</sup>, has a great potential for change due to its replicability. The international databases on plant species and their needs (mainly regarding temperature and rainfalls) are growing and are available to all. The Climate Assessment Tool (CAT) of the BGCI for tree species has already been used by the Botanic Garden of Pisa, for example, to determine the vulnerability of its arboreta collection.<sup>35</sup>

The Section 3.3 concludes the thesis by exploring the applicability of these analysis tools to Italian botanic gardens and their initial results. After the overview of the research carried out in Pisa, I worked on recreating a similar study on the collection of the Botanic Garden of Bergamo.

These avant-garde innovative approaches of technological advances in climate modeling applied to plant conservation can represent both a challenge and a hope for future efforts. However, they are not free from critical implications: are we trying to accept and live with the change or are we trying once again to control nature?

Botanic gardens have the peculiar characteristics of being living museums, full of contradictory objectives, such as preserving something that is alive and naturally mutates over time. Maintaining collections out of their context and treating them as objects of study without remembering their relations with other beings will not really be useful in understanding plants and neither protect them in a holistic way.

In the end, the conclusions will gather these sorts of concerns and unsolved issues that botanic gardens carry with them since long ago and that are becoming more complex to disentangle in an epoch full of global crises.

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<sup>34</sup> Royal Botanic Gardens Victoria. 2018. *Climate Change Alliance of Botanic Gardens Charter*. <https://www.rbg.vic.gov.au/media/iknn4jaw/climate-change-alliance-of-botanic-gardens-charter-full-version.pdf>

<sup>35</sup> M. D'ANTRACCOLI, N. WEIGER, L. COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios: What Are We Walking into?*. *Sustainability*, 15, 4585.

## Chapter 1. Result and Driver of Change, Botanic Gardens Through History

### 1.1 The Origins

The ideal definition of a botanic garden following the current standards is fairly complex and touches many points. It would correspond to an institution which physically hosts a living collection of plants, precisely catalogued, while pursuing actions in favor of biodiversity conservation, increased public and scientific awareness, education and, last but not least, aesthetic pleasure.<sup>36</sup> So it is described according to the Botanic Garden Conservation International (BGCI), one of the most relevant associations globally for the representation of botanic gardens, of which we might discuss more in detail further on.

The number of botanic gardens that are officially recognized today accounts for around 1775 spread through 148 nations and it seems a growing trend,<sup>37</sup> even though maybe not all of them can match such a high standard definition. Moreover, as if all previous characteristics were not enough, in recent years there is a growing attention to the inclusion of ethical, political and sustainable considerations within the activities and management of gardens.

United in the aspiration for embracing such values, there is a great array of incredibly diverse gardens around the world, each of them with a different story, a different feeling, and a different multi-species assemblage.

But how was this definition reached? Can actually an institution be so versatile and efficient to carry on multiple initiatives belonging to different fields while creating a bridge between the natural world and the man made world?

Right now, this picture is not easy to put together. Thus, it is necessary to take some distance from our present and deconstruct the topic, in order to address it one layer at a time, until the final image will reconstruct itself in our minds in a much more complete way.

Yet, even picking a starting point can be critical: to understand what a botanic garden is, we could ask ourselves what is a garden and why did humans ever create them; however, digging deeper, this thread might lead us into the much wider discussion on what is the relation between humans and plants.

The primordial role of plants for the sustenance of life on Earth has been generally accepted, yet it is never stressed enough. They truly are the primal energy source for all living beings and humans managed to find many more ways to exploit them not only for supplying food, but for

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<sup>36</sup> BGCI. (Last visited 23 November 2022). *Botanic Gardens and Plant Conservation*.

<sup>37</sup> BGCI. (Last visited 23 November 2022). *Botanic Gardens and Plant Conservation*.

construction, medication, textiles creations, ornamental purposes and much more through the millennia. The intrinsic correlation between the vegetal world and humanity from its oldest days, is undoubted.

For this reason, to avoid the risk of opening a digression that would be too broad, I will try to focus on the evolving human-plant relation within the context of garden design and horticulture. Nonetheless, the road to get to the modern recognition of botanic garden institutions remains very long and it reaches quite back in time. Thus, I invite you to sit back and enjoy this time travel with me.

We shall start as far back as 10'000 years ago, some of the earliest days of mutual plant-human cooperation, when the first intentional gardening activity was based on one need: the primordial need for food stability.

What was happening at the time is called proto-agriculture, the beginning of comprehension and exploitation of the life cycles of natural elements. Indeed, there is archaeological evidence that during the Neolithic period some communities started not only to be more sedentary, but to actively grow some crops where they would settle.<sup>38</sup> Some of the most relevant staple food crops intensively cultivated today can be traced back to this period's "8 founder crops", of which ancestors of emmer wheat, barley, chickpea and lentil are an example.<sup>39</sup> This is considered the first agricultural revolution in the history of humanity, a major turning point; yet, there is more to be impressed by.

One fundamental aspect we have to keep in mind during our journey, that will be relevant for our later considerations, is the understanding that also non-human beings have agency: when humans decide to adapt their lifestyles to the vegetal cycles, so does the flora. In fact, returning to the expression mentioned previously, "mutual plant-human cooperation", this turning point was not only an anthropogenic revolution.

And the proof of this mutual influence lies within archaeological remains of plant seeds recovered at historical sites: they revealed a different structure compared to their wild counterparts. For instance, the bond that connects the seeds to the mother plant became stronger, because there was no more need of the wind for carrying them to new colonizable land.<sup>40</sup> Humans were the new insurance on the species reproduction for those plants. The dimensions

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<sup>38</sup> Mark B. TAUGER. 2011. *Agriculture in World History*. Routledge. p. 4-5

<sup>39</sup> Annette GIESECKE. 2022. *A Cultural History of Plants* (Vol.I In Antiquity). Bloomsbury Academic. p.19

<sup>40</sup> TAUGER. 2011. *Agriculture in World History*. p. 4-5

increased as well, in a safer environment or simply more cared for, the plants do not need to save energy elsewhere, they can give their best to the seeds.<sup>41</sup>

This phenomenon is called domestication and it encompasses a set of emerging desired or undesired modifications in plants or animals induced by the cohabitation with humans.

Nonetheless, moving away from an anthropocentric view, it can be argued that the term domestication does not really reflect the agency of plants in this long process. There cannot be a certainty that said changes were an innate trait and were then preferred by the first farmers or, vice versa, that they were an adaptation to human activity. It has been more likely a mutual reaction.

With a slow pace, millennia pass by and, eventually, around 3'000 years B.C. historians agree that agriculture was becoming a fully developed practice in different parts of the world, allowing cultures to strengthen and to explore new aspects of life.<sup>42</sup> Cultivated land was associated with life force and growth since better farming abilities meant a raise in demographic numbers. This originated an endless cycle which is still perpetuated in current times in a way that would be defined by Eriksen as a runaway process, thus the combination of mutually reinforcing activities destined to eventually reach a critical collapsing point.<sup>43</sup>

However, in the past, the rupture point was still very far and reinforced processes of demographic and agricultural growth turned into a real political force when the earliest city-states emerged and, later on, laid the way to the birth of ancient empires such as the Assyrian and the Babylonian.<sup>44</sup> And it is here in Mesopotamia that the first examples of gardens appear,<sup>45</sup> because where there was development there were also great horticulturists. The myth of the Hanging Gardens of Babylon, whether it corresponded to a physical or only an imaginative garden, signaled a surge in landscape design creativity and passed down through generations influencing even the later Romans.<sup>46</sup>

Another step in the evolution of a different conception of gardens is attributed to Neo-Assyrian gardens around 700 B.C., when rulers like Sargon II saw in gardens the power of representation.<sup>47</sup>

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<sup>41</sup> GIESECKE. 2022. *A Cultural History of Plants* (Vol.I In Antiquity). p.19

<sup>42</sup> G. PRANCE, M. NESBITT. 2005. *The Cultural History of Plants*. Routledge. p.2

<sup>43</sup> T.H. ERIKSEN. 2016. *Overheating. An Anthropology of Accelerated Change*. PlutoPress. p.21

<sup>44</sup> GIESECKE. 2022. *A Cultural History of Plants* (Vol.I In Antiquity). p.20

<sup>45</sup> BGCI. (Last visited 23 November 2022). *Botanic Gardens and Plant Conservation*.

<sup>46</sup> Kathryn GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. *A Cultural History of Gardens: Vol.I*. Bloomsbury. p.29

<sup>47</sup> GIESECKE. 2022. *A Cultural History of Plants* (Vol.I In Antiquity). p.158



The use of exotic plants to recreate a space out of place resembles much more the ornamental purposes conceived in modern western cultures, even if there was no distinction between purely ornamental plants and productive plants such as fruit trees or vegetables. In any case, for an empire leader, having a garden composed of exotic plants, either retrieved or gifted from conquered lands, was a living representation of the vastness of the empire itself, a symbol of power, strength and appropriation. A horticultural trick used for this purpose by the Assyrians, as well as from the Egyptians before them, was that of the “sunken gardens”: the excavation of land below the surface level to create an environment more protected from wind and aridity, preventing humidity to escape and sustaining the life of certain non native plant species.<sup>48</sup> This is an early example of human capability to alter the microclimate of a territory.

While appreciating the marvels of nature, humans were beginning to master it for their own purposes. However, there were still many limits to such mastery and respect for nature itself, in his benevolent or destructive forms; it is no coincidence that several ancient cultures adored Gods that were the living representation of natural elements. One of the most classic examples are the Egyptian deities, such as Nut (the sky goddess), which at times can be found represented in the form of a Sycomore tree bearing gifts.<sup>49</sup> Also agriculture was so relevant at that time that it withheld a spiritual meaning, as the Field of Reeds, the afterlife paradise representing a farming land of perennial abundance. There are records of artistic representations, especially inside Pharaonic tombs dating up to 1550 B.C., from which we can deduce how garden spaces were places of conjunction between the human world and the supernatural world of the Gods.<sup>50</sup> In a similar manner, plants themselves withheld practical powers for their uses in men’s hands and higher meaning in reference to religious myths, traditions and ceremonies: for instance, date and doum palms were associated with the rites of resurrection and could be found at the entrance of sacred temples.<sup>51</sup>

At first we witnessed a need for food and, thus, plant cultivation; now more layers start to appear together with the pleasure for natural elements and thus the creation of the first gardens, such as display of political power or the creation of a sacred place of encounter with something more than human, imbued with spiritual beliefs.

The Greeks and, subsequently, the Romans, also added different values to the gardens. Luckily, the Hellenic civilization left us many written sources of their thoughts and their encounters with

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<sup>48</sup> GIESECKE. 2022. *A Cultural History of Plants* (Vol.I In Antiquity). p.159

<sup>49</sup> Alix WILKINSON. 1998. *The Garden in Ancient Egypt*. The Rubicon Press. p.99

<sup>50</sup> Kathryn GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. p.125

<sup>51</sup> WILKINSON. 1998. *The Garden in Ancient Egypt*. The Rubicon Press. p.107-108

others and, in particular, there is one term that has been imported from the Persian empire useful for our research: the *paradaiza* (walled enclosure), gardens of the Persian aristocracy, transliterated as *paradesoi* in Greece (from which it derives the modern term *paradise*). Although they were a classic example of exhibition of economic and political power, as it happens for many concepts when transposed into a different context, it assumed a different meaning. In particular, the Greek philosopher Xenophon was so impressed by the Great King of Persia's care in attending his garden equivalent to his attention in approaching war to the point that he compared the management of gardens to good governance.<sup>52</sup> This new value of just governance associated with horticulture did not take root much, but it was the starting point for a new set of social and ethical values that will flow into the κηπος (képos), beautifully managed gardens.

There was not an abundance of arable fields in the Greek domains, and the competition was high, so there was not as much possibility for monumental gardens as intended in the ancient past. However, small gardens started to be an integral part of urban cities as they acquired a more sophisticated value. In particular, *képos* became common areas for philosophical and social discussions among erudite elites since the time when the most relevant Academy in Athen gained a garden; intellectuals slowly got acquainted with the idea that such spaces can favor the thinking processes of the mind. We all share the image of Plato and Aristotle walking in gardens while discussing with their disciples. Thus many individuals after them would add a garden to their school as a semi-public space of social interaction and education. One of these figures is Theophrastus, who is considered the father of botany as he is the author of one of the earliest set of manuscripts on plant biology, *Historia plantarum*.<sup>53</sup> (which will later on be revived and translated into Latin during the Renaissance.)

Afterwards, the Romans inherited much of the past influences not only from the Hellenic world, but from all over the Mediterranean basin. From the archaeological data that were retrieved, it was possible to reconstruct some scopes of horticultural abilities: in early cases gardens were designed still as a tribute to religious divinities, but slowly they started to be used mostly in conjunction with great aristocratic villas, as a symbol of aspirational social status.<sup>54</sup> The House of the Menander and the House of Octavius Quartio in Pompeii are examples of garden villas.<sup>55</sup> In a growing empire such as the Roman one, which continued to expand all over the European continent, there were many opportunities for encounters as much as for territorial

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<sup>52</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.129

<sup>53</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.131

<sup>54</sup> Katharine T. VON STACKELBERG. 2009. *The Roman Garden: space, sense and society*. Routledge. p.11

<sup>55</sup> VON STACKELBERG. 2009. *The Roman Garden: space, sense and society*. p.101

acquisition, and being a landowner meant having power. Similarly to past populations like the early mentioned Assyrians, gardens turned to be much more about showing off the economic status of a person than about the sacredness of nature or philosophical wonderings. Moreover, in their materialistic culture, one perspective that was gladly borrowed from the Greeks is the hedonistic philosophy of finding pleasure in nature. Thus, pleasure and power were the guiding ideals behind the Roman experience of garden design.<sup>56</sup> In fact, they were more considered like artistic monuments than living beings, as proven by the combination of living and inert media such as stone sculptures and planters, let alone the transformation of bushes themselves into objects through the art of topiary.<sup>57</sup> Romans considered themselves true masters of nature, which was meant to be malleable and could take multiple shapes as the theatre stage for social encounters.

It is interesting to notice how, at the end of the Roman times, the introduction of Christianity targeted certain cultural assets while others were maintained; for instance, the sacrality of gardens connected to religious pagan beliefs was mostly demolished, yet the new elites did not dislike the privileges of private gardens to the point that palace gardens resisted as a form of design during the subsequent historical phase.<sup>58</sup>

Indeed the little we know of the Middle Age is connected to the few feudal elites that were the only ones who owned enough resources to adorn their residences with gardens and would keep them as private as possible. Within the European context, the majority of the population did not have enough resources to explore aspects of gardening that went further the basic need for food and medicinal herbs; the elites only could afford economic and territorial accumulation.

In this context, we cannot avoid considering ecclesiastical entities as an elite in themselves. Churches took upon themselves the role of benefactors and knowledge accumulation centers. And they hosted the most common forms of gardens of the Christendom Middle Ages: monastic gardens. From these it takes origin the attempts at recreating an earthly garden of Eden where humans could find a rightful purpose as intended by God.<sup>59</sup> An *hortus conclusus* (enclosed orchard) was often at the core of monasteries to ensure food supply for the monks themselves, while an

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<sup>56</sup> VON STACKELBERG. 2009. *The Roman Garden: space, sense and society*. p.73

<sup>57</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.97

<sup>58</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.74

<sup>59</sup> Michael LESLIE. 2013. *A Cultural History of Gardens in the Medieval Age*. A Cultural History of Gardens: Vol. 2. Bloomsbury. p.2-3

*hortus simplicium* was dedicated to the cultivation of officinal plants that could be directly used as pharmaceutical remedy.<sup>60</sup>

For a long time there were not many accessible gardens, as testified by the poor imagination in artistic representations of early christian art. It was only from the beginning of the first millennium that they began to show more details in depicting the idyllic garden of Eden,<sup>61</sup> laying the base for the modern conception of it.

Although mediaeval times are considerably less studied in garden history due to being generally regarded as a dark period lacking much innovation, this can just be reconnected to a general fragmentation of power and impoverishment of the large majority of individuals, of which we have very little records. And it is important to point out that this is valid when discussing the European context, but elsewhere in the world cultures were flourishing as well as garden experimentation. Some examples are recorded in the Americas, by pre-Columbian cultures, and in Asia, in particular in China and Japan.

Before the physical and cultural invasion of Europeans into the American continent, there have been innumerable ethnic groups, concentrated in the Mesoamerican regions, that could rival with many others for their horticultural advancement. Their traditional knowledge, as it would be called today, included many techniques of interest. For example, it is of Mesoamerican origin the combination of the “Three Sisters”(maize, squash and a variety of bean).<sup>62</sup> If grown together, instead of separately, each crop can contribute to the growth of the others: corn can offer a tall standing trail for beans to climb up, while the beans offer specific nutriment to the soil that others benefit from and the squash with its large leaves protects the plot against soil droughts with their shade.<sup>63</sup>

Some gardens that did not go unnoticed by the Europeans, and of which they left us some descriptions, are the Monumental gardens of the Aztec.<sup>64</sup> One of the most important is the garden of Tzeczotzingo, which is even considered by some a precursor of botanic gardens for its biological collection of local specimens. These were showcased on terraces, which were the Mesoamerican agricultural adaptation to an unstable and limited land, in order to supply for demographic rise

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<sup>60</sup> A. VIOLA, M. SPECIALE. 2021. *Andare per Orti Botanici*. Il Mulino. p.9

<sup>61</sup> LESLIE. 2013. *A Cultural History of Gardens in the Medieval Age*. A Cultural History of Gardens: Vol.2. p.15-17

<sup>62</sup> A. J. LANDON. 2008. *The "how" of the three sisters: The origins of agriculture in Mesoamerica and the human niche*. Nebraska Anthropologist, Vol. 23. p.113

<sup>63</sup> Joy HENDRY. 2014. *Science and Sustainability. Learning from Indigenous Wisdom*. Palgrave Macmillan. p.39

<sup>64</sup> P. AVILÉS. 2006. *Seven ways of looking at a mountain: Tetzcotzingo and the Aztec garden tradition*. Landscape Journal, 25(2): 143-157. p.143

while reducing risks of crop loss due to rapid changes in climatic conditions. Terraces could also be the perfect earthy transposition of the structure of the universe according to Aztecs, who use them in temples as well. Spiritual and agricultural values, merge with artistry both through landscape design and other forms of craftsmanship incorporated in the site design: statues, drawings and inscriptions narrating historical events of the reign empowerment.<sup>65</sup> Tetzcotzingo is an incredible archaeological site that gathers many cultural aspects of the Aztec tradition and proves to us how wide the functions and meanings of a garden can actually be.

Meanwhile, on the other side of the Pacific Ocean, also the Asian continent during the first millennia went through incredible transformations, especially after the birth and expansion of the Chinese empire. In the past there have been cases of great elitist garden parks, such as “the Supreme Forest” created during the first imperial Qin dynasty (3rd century B.C.), surrounded by a 300 km wall to host more than 3’000 botanic species and illustrate the scale of the emperor’s power himself and to function as an amusement hunting park.<sup>66</sup> Yet the most interesting development for garden conception took place later on, together with cultural and social transformations thanks to the imprints of Confucianism, Taoism and, later on, Buddhism. And the same goes for Shintoism and Zen Buddhism in Japan. One value they all had in common was to see humans and nature together as one.<sup>67</sup> No matter the innumerable changes of time, these ideologies were so strong and pervasive that, in some ways, persisted until modernity and it is evident in most famous Asian garden styles, which are so different from the western ones.

Gardens in China and Japan were places of pleasure, yet in a more spiritual way. And they were meticulously constructed through the use of symbols, as for the dry gardens (枯山水, *karesansui*), in which pebbles represent the water and larger stones are the mountains.<sup>68</sup> In most cases, whether on a small or large scale, they all represented a specific scenery evocative of real life locations, helping the observer to escape reality, find purity and reach a higher state of illumination.

In the end, no matter the variety of cultures, plant species and garden styles around the globe, the birth of the first botanic gardens is attested in the 16th century in Europe, the continent that

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<sup>65</sup> AVILÉS. 2006. *Seven ways of looking at a mountain*. Landscape Journal. p.146

<sup>66</sup> GIESECKE. 2022. *A Cultural History of Plants (Vol.I In Antiquity)*. p.160

<sup>67</sup> Yolaine ESCANDE. 2018. *Giardini di saggezza in Oriente (Jardins de sagesse en Chine et Japon)*. Trad. Maruzza Loria. Derive e Approdi. p.14-15

<sup>68</sup> ESCANDE. 2018. *Giardini di saggezza in Oriente (Jardins de sagesse en Chine et Japon)*. p.55

would soon redefine itself as the centre of the world after the discovery of the American continent.

And what site could suit them better than former monasteries, the withholders of economic and wisdom power during the Middle Age, especially in the Italian peninsula. Here, in Pisa, and Padova almost simultaneously, the first botanic gardens were inaugurated in 1544 and 1545, while the Italian Renaissance was blossoming, the scientific revolution was at its dawn and universities were ready to supplant the clerical institutions as main knowledge accumulation centers. Thus, the oldest botanic gardens found their birth in previous *hortus conclusus* that belonged to monasteries.<sup>69</sup>At last, we reached the birth of botanic gardens.

It might seem unnecessary to have taken such a detour to reach what we consider as just a beginning, yet in a way life has a hidden circularity in itself and I believe it to be the case also for the history of botanic gardens, which are a very peculiar branch within a broader garden history. Values and ideals are never lost, but simply transformed and, we could say, recycled to create something new. And the values previously mentioned of need for sustenance, aesthetic aspirations, spiritual connection, political and economic power display and philosophical research, they all contributed, either directly or indirectly, and merged into the up-cycled concept of botanic gardens.

These original gardens were innovative because they were meant as living open laboratories, places to study on the field, opposed to the mainstream study of classical texts from the past. The Renaissance was the consequence of the 15th century recovery and elevation of classical texts from the Greeks and Romans and the translation of such texts to better share such knowledge. For example, the *Historia plantarum* of Theophrastus, was then translated into Latin, since it was more in use among scholars at the time.<sup>70</sup> Another relevant text for medicine as for botany was the *De materia medica*, originally written by Dioscorides in the first century A.D., which included the description of hundreds of medical substances deriving from animal, mineral and plant sources.<sup>71</sup> These texts were undiscussed masterpieces within university institutions for medicine teaching and they would reveal themselves as fundamental steps for the subsequent affirmation of botany as a subject separate from medicine. Yet this passage could not have taken place without botanic gardens.

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<sup>69</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.9-10

<sup>70</sup> GLEASON. 2013. *A Cultural History of Gardens in Antiquity*. A Cultural History of Gardens: Vol.I. p.131

<sup>71</sup> Silvia FOGLIATO. 2021. *Orti delle Meraviglie: i giardini botanici e la diffusione planetaria delle piante*. Derive e Approdi. p.23

The study of plants at the time was a necessary step within medicine and pharmaceuticals, as they were main ingredients for remedies of all sorts. However, such knowledge needed a proper categorization and standardization. Not only was misidentifying beneficial plants a common mistake due to misleading drawings or incomplete descriptions of plant specimens in old manuscripts, but false remedies were also spreading by the hands of frauds.<sup>72</sup> Thus, medicine professors with a strong will, like the first director of the Paduan Botanic Garden, Francesco Bonafede, realized the importance of teaching students hands-on life itself.<sup>73</sup>

The creation of the first *herbarium* by Luca Ghini, was another step in consolidating botanic gardens as centers of knowledge accumulation because it was a means of turning subjects into objects, simplifying their systematization, transport and management. Ghini was the first to create a botanic garden, financed by Cosimo I De Medici the Duke of Tuscany, after he accepted in turn to teach medicine at the University of Pisa. He learned how to best dry plant samples to preserve them as *exsiccata* and taught said procedure to his students as well.<sup>74</sup> Representing botanical archives, more similar to other museal structures, *herbaria* will be considered an integral part of botanic gardens from then on.

Resembling the Greek gymnasias, botanic gardens slowly became an integral part of educational institutions, but in a more utilitarian perspective.

Indeed, this format quickly diverged from the art of landscape design, delineating two separate but parallel currents, one researching aesthetic beauty, the other aiming for functionality and scientific research.<sup>75</sup> Italy was a leader in the arts and in education at the time, but these worlds cannot be considered as immune from one another, thus even if there were consistent differences between botanic and ornamental gardens, there were and there will always be infiltrations along their development. For instance, the showcase of exotic objects or plants was becoming popular especially among rich collectors under the wunderkammer influence.<sup>76</sup> Wunderkammern were special rooms dedicated to the archiving of strange rare artifacts of all sorts, which were retrieved during travel expeditions, and were becoming more and more common in the 15th and 16th

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<sup>72</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.9

<sup>73</sup> Elizabeth HYDE. 2013. *A Cultural History of Garden in the Renaissance*. *A Cultural History of Gardens: Vol.3*. Bloomsbury. p.57

<sup>74</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.26

<sup>75</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.11

<sup>76</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.22

century.<sup>77</sup> And part of this idea of awe for what is foreign and peculiar was incorporated in private as well as in botanic gardens, which most of the time include non-native plants for their appearance or rarity, more than their utility. Nonetheless, there is no doubt that aesthetic research in botanic gardens was not the priority, compared to their scope of being new means of teaching.<sup>78</sup>

It cannot be forgotten that from the beginning of the 16th century the European expansion to new continents was a massive source of exchange of new ideas and new forms of life. The retrieval of plants from the New World made it obvious that all the knowledge sources of the time were merely the tip of the iceberg of a much unexplored realm and the tools to describe it were inadequate.

The research for better ways of classification, as well as complete understanding of plant biology, became an open challenge. Field explorations and writing of personal diaries were common activities for naturalists who sought the encounter of more species to create newer categories based on plant reproduction or morphological structure.

But what to do with all the observations and data? How to share and get recognition for one's findings? Botanical gardens soon became the safe destination and trading centre of both ideas and physical samples for intellectuals, pharmacists, doctors and plant collectors. There, knowledge could take final shape and be made public, confirming that even from their most primordial examples, botanic gardens' socio-cultural role was interrelated with their scientific and economic role.

Among the reasons for Italy's blossoming during the 16th century there was the growing interrelations between noble elites, who were ready to use their finances to make political statements, and literate innovators in the arts and sciences. Thus, it was one of the preferred destinations for scholars from all of Europe to visit and learn the latest trends, including the newest botanic gardens. However, such supremacy did not last forever.

During their travels, some individuals were so impressed by the Italian botanic gardens that they eventually found a way to reproduce such model abroad. Like the first attempt in Montpellier by Guillaume Rondelet in 1550<sup>79</sup> or the one in Jena in 1568 by the German medicine

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<sup>77</sup> J. G. HARRIS. 2000. *The new new historicism's Wunderkammer of objects*. *European Journal of English Studies*, 4(2): III-123. p.115

<sup>78</sup> M. MOSSER, G. TEYSOT. 1991. *The History of Garden Design. The Western Traditions from the Renaissance to the Present Day*. Thames & Hudson. p.81

<sup>79</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.52



professor, who studied in Padua, Johann Schröter.<sup>80</sup> Indeed, other centers of education in Europe, Universities with a medicine chair, eventually adapted to this innovative teaching method of joint theoretical and practical learning. In fact, within a century, similar botanic gardens appeared in France, Germany, the Dutch Republic and the United Kingdom.<sup>81</sup>

Meanwhile, the world was undergoing a massive metamorphosis; it was the beginning of the expansion of maps, connections, trades and power on a global scale. The means for exercising said power were changing and gardens were an integral part of these worldwide growth processes.<sup>82</sup> While following the trail of botanic gardens in the rest of the European continent, the next section will analyze how botanic gardens networks become a global phenomenon and, in parallel, how the science of botany gains more and more its independence as a field worth standing on its own also due to its interconnection with imperial powers.

### *1.2 Imperialism and Colonialism*

Although Italy was the birthplace, other nations strengthened the role of botanic gardens until they became actual political and economic forces. The physical context and the society has an influence on the use and design of gardens, contributing to their peculiar differentiation and, as previously mentioned, the first to replicate botanic gardens were the French.

It is in 1593 that Richer de Belleval obtained the approval of the Monarch, supported by his protector the governor of Languedoc Henri I de Montmorency, to create the first botanic garden of France, annexed at the University of Montpellier.<sup>83</sup> It was a political and economic business, and this leads us to an important consideration: the strategic location of botanic gardens.

It is not by chance that in several cases, botanic gardens would appear in thriving cities, places of mercantile exchanges like harbor towns, as it was clearly shown by the *Horti simplicium* in Padua, within the Venetian Republic. The *Jardin du Roi* in Montpellier, first, but others after this, exemplify the fact that the best position for botanic gardens would be in places of exchange, which often include a movement of information, people and goods, like plants and seeds.

Montpellier was the perfect city. It hosted a university, famous for its medicine faculty, and it had one of the most important harbors in his time, until the main trading routes moved out of the Mediterranean from the end of the 17th century. It can be said that it resembled Venice for being a

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<sup>80</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.90

<sup>81</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.8

<sup>82</sup> HYDE. 2013. *A Cultural History of Garden in the Renaissance*. A Cultural History of Gardens: Vol.3. p.4

<sup>83</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.65

famous port for spice commerce, from which goods could be transported easily to Spain or to continental Europe.<sup>84</sup> Belleval was, indeed, inspired by his travels in Italy and to the *Hortus* of Padua. He was so determined that he eventually managed to obtain the separation of the faculties of medicine and botany in Montpellier University. And by 1622, before the garden would be ruined by inner conflicts, he managed to create a collection of 1300 different species of plants, ranging from exotic to local.<sup>85</sup> It was the prelude to the *Jardin des plantes medicinales* of Paris, which was founded much later, but was the ameliorated version of the one in Montpellier, both in terms of dimensions and richness.

The botanic garden of Paris can be considered as the greatest achievement in Guy de La Brosse's life, the personal doctor at the court of the King of France Louis XIII. Promoted and financed by de La Brosse, he got the first approval in 1626, but the actual garden only opened to the public in 1640. The project went against the Faculty of Medicine, because university professors had the monopoly on medical knowledge and did not want the monarchy to intrude in their business. The battle of power was fought in terms of personal credibility against La Brosse, for his miscredited ideas on medical teachings that involved experimental practices like chemistry, opposed to traditional ones. But thanks to the protection of the Monarch, who saw it as the opportunity to promote a monumental opera in favor of the royal image, La Brosse was able to win his battles for innovation and to create one of the grandest gardens in Europe. Initially meant for the implementation of medicinal plant studies and supply for local pharmacists, the botanical garden of Paris was an incredibly rich royal institution which not only survived his founder's death, but even the four centuries that came after him.<sup>86</sup>

Moving our attention to Continental Europe, we start to see some innovation in the very divided Germany of the 16th and 17th century. Germanics were not directly innovative in the gardens per se, but in two ways connected to our botanic historical journey: first, for stressing the relevance of learning about local flora, even widening the attention to common weeds, and, secondly, for their application of Gutenberg's printing invention to botany.

Concerning the first point, when the habits of practical observation in the field started spreading to northern Europe many German scholars and naturalists quickly realized that much of what was taught to them through the famous Greek and Latin texts, was very dissimilar from

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<sup>84</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.49

<sup>85</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.67-68

<sup>86</sup> R. HOWARD. 1974. *The founding of the Jardin des Plantes in Paris. Proceedings of the ... Annual Meeting of the Western Society for French History*. Western Society for French History. Meeting, 2:138–150.

the reality surrounding them. In fact, for the most part, ancient documents academically studied in medical faculties contained information on Mediterranean flora.<sup>87</sup>

One of the earliest figures that publicly demonstrated the impossibility of applying for instance Greek categorizations of Dioscorides to the German flora was Euricius Cordus. Cordus expressed his theories in the only text that he ever published concerning plants, the *Botanologicon*, and for which he passed down to history as one of the fathers of German botany, more than for his poetical and medical accomplishments. In addition, his passion for the natural world was so influential that his son, Valerius Cordus, inherited it too and contributed greatly to the compilation of a great detailed plant index with the posthumous published manuscript *Historia Plantarum*.<sup>88</sup>

On the other hand, concerning the second point of innovation mentioned earlier, Fuchs is the major exponent of the evolution of botanical iconography. Leonhart Fuchs (1501-1566) is responsible for being among the leaders in raising the standards of printing image quality, as can be seen in *De historia stirpium commentarii insignes* (1542), translated as “Remarkable commentaries on the history of plants”.<sup>89</sup> As pointed out, his strength was not much in the study of plants: in fact, in his publication plants are not categorized under possible groupings, or any systemic division as other botanists were trying to achieve, but simply according to alphabetical order. Nonetheless, he revolutionized the printing process striving for perfection in representing nature and he even mentioned the team of artists that cooperated to such an immense result in the final copy: Meyer, the painter, did the drawings of living plants; Füll, the copier, transferred the drawings on woodblocks; finally, Spreckle the sculptor would carve the wood matrix for the printing and subsequently even aquarelle painted some copies for the limited luxury editions.<sup>90</sup>

Fuchs believed in the power of images, to overcome the uncertainties in botanical identification.<sup>91</sup> He may have not achieved his goal, but he certainly contributed to the spread of botanical interest and fascination to a larger audience.

Following the path of the printing industry opened by Fuchs, another influential figure that was able to exploit this new technology to its maximum communicative potential is Conrad Gessner. He was a Swiss naturalist, mostly known for his attempt at creating a universal library, a

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<sup>87</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.79

<sup>88</sup> M. A. HOWE. 1910. Review Greene's Landmarks of Botanical History. p.155

<sup>89</sup> S. KUSUKAWA. 1997. *Leonhart Fuchs on the Importance of Pictures*. *Journal of the History of Ideas*, 58(3): 403-427. p.403

<sup>90</sup> KUSUKAWA. 1997. *Leonhart Fuchs on the Importance of Pictures*. p.404

<sup>91</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.88

catalogue of all existing texts and writers in Latin, Greek and Hebrew. In fact, he saw the print as the means to prevent texts, and thus knowledge, to be lost through time.<sup>92</sup> He applied his talent for accumulating and cataloguing data in many directions and topics and it is thanks to him that in 1561 it was published probably one of the first ever books on gardens and gardening, the *De Hortis Germaniae*. The text contained an alphabetical catalogue of all known German gardens until then.<sup>93</sup>

The printing press was not just mere technology, but a communication tool to spread and display values, ideas and the fashion trends of the time. The diffusion of botanical texts, florilegia and naturalia would go hand in hand with the spread of botanical interest among collectionists and elites, in particular in England, as we will see later. Without the development of prints, the later Linnaean taxonomic theory of the 18th century might not have had such a wide audience all over Europe and the world for instance.

Now, moving back to botanic garden institutions, we talked a lot about passionate botanists and educational gardens with medical plants, but soon enough things started to rapidly change. The economic importance of botany will bring them to a new level.

However, before moving on to further examples, it is necessary to make a brief premise on the choice to focus this section mainly on two nation-States: the Dutch Republic, also known as the United Provinces, and the Kingdom of Great Britain. Such choice is dictated by the desire to stress how it is hardly a coincidence that the development of the economic and political potential of botanic gardens on a more global level is strictly interrelated to these two nations, which represent the first two worldwide hegemonic powers which transitioned one after the other and led to modern times.<sup>94</sup>

As Arthur Hill wrote in the incipit of his essay on the history and functions of botanic gardens: “There are three things which have stimulated men throughout the ages to travel far and wide over the surface of the globe and these are gold, spices and drugs.”<sup>95</sup> Indeed, it was the desire for spices, a luxury trading products from the East, that pushed the Iberian empires to lead the

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<sup>92</sup> Ann BLAIR. 2017. *The 2016 Josephine Waters Bennett Lecture: Humanism and Printing in the Work of Conrad Gessner*. In: *Renaissance Quarterly*. Cambridge University Press. 70(1):1-43. p.9

<sup>93</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.80

<sup>94</sup> G. ARRIGHI, B. J. SILVER. 2006. *Caos e Governo del Mondo, (Chaos and Governance in the Modern World System)*. Bruno Mondadori. p.43

<sup>95</sup> A. W. HILL. 1915. *The History and Functions of Botanic Gardens*. *Annals of the Missouri Botanical Garden*, 2(1/2): 185–240. p.185

exploration race,<sup>96</sup> initially aiming at Asia, but inadvertently bumping into the New World, the American continent.

Nevertheless, even though Spanish and Portuguese led the way and were the first to create oceanic trade routes, the first hegemonic title is to be assigned to the Dutch. This is due to the fact that they were able to take advantage of the new wide web that was being built by other nations and monopolized the economy through their technological advantage and mercantilism.

Since the end of the 16th century, until the official recognition with the Peace of Westphalia (1648),<sup>97</sup> the Dutch Republic started flourishing, slowly imposing itself as rulers of the seas for their shipbuilding abilities. Yet it was just the beginning, due to the increasing dimensions of trades, resources and businesses, advanced financial management and consistent funding were more and more a necessity. And right at the beginning of the 17th century, the first joint stock companies were created in the Dutch Republic and England, immediately followed by the first ever market stock exchange based in Amsterdam (1602). Even though the British were technically the first to create the East India Company (EIC) in 1601, the Dutch were definitely most successful in the beginning of this new venture with the United East India Company (*Verenigde Oostindische Compagnie*, VOC), founded in 1602, which enormously contributed to the so called “golden age” of the Dutch Republic.<sup>98</sup>

These companies’ success can be attributed to several factors of economic, juridic, political and technological nature. An enlarged world could represent an enlarged market, thus there were tremendous opportunities for enrichment, as well as for losses. With the objective of raising and managing larger sums of money while reducing the risks, the VOC’s creation was the perfect option as the ancestor of modern limited liability companies. Administrators had no responsibility for the company’s debts and shareholders had no power in the decision making, allowing for the company to take more hazardous decisions in light of possible higher long term profits.<sup>99</sup> This step is crucial to understand the development of capitalist mentality, based on the accumulation of capital as a chance for continuous growth. Although there was a strong bond

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<sup>96</sup> Lucile H. BROCKWAY. 1979. *Science and Colonial Expansion: the Role of the British Royal Botanic Gardens*. Studies in Social Discontinuity. Academic Press. p.49

<sup>97</sup> ARRIGHI, SILVER. 2006. *Caos e Governo del Mondo*. p.43

<sup>98</sup> J. NIJMAN. 1994. *The VOC and the expansion of the world-system 1602–1799*. Political geography, 13(3), 211-227. p.214-215

<sup>99</sup> NIJMAN. 1994. *The VOC and the expansion of the world-system 1602–1799*. p.219

between the state's interests and the company, from then on, it began the slow switch of powers from noblemen and royalties to the emerging merchant class.<sup>100</sup>

Among the other elements of success we find a flexible structure, very decentralized, which was open to change plans depending on the most profitable outcome, in particular in Asia. And last but not least, the Dutch technological and scientific monopolies of the 16th and 17th century on cartography and shipbuilding were an essential part of the long life of the VOC's revenues.<sup>101</sup>

It naturally emerges the question of how botanic gardens fit in this context. They do fit because the increased importance relegated to mercantile powers went hand in hand with the scientific research on botany.

Although the first gardens in Holland were born in the aftermath of the European trend that started in Italy and was spreading in France, they eventually took a profoundly different direction. Indeed, it is with the Dutch that botanic gardens were about to change forever their historical role, by redirecting their main objective from educational to economic gain. They became centers of accumulation by studying and reproducing newly discovered exotic species and acclimating plants of economic interest, either for European horticulturists and collectors or for laying the basis for abroad plantations.

To see how this change took place, we will focus on the two oldest and most relevant botanic gardens in the Netherlands: the botanic garden of Leiden and Amsterdam.

The oldest botanic garden in Holland dates back to 1590, in Leiden, where the recently founded University was in need of an *hortus academicus* to support the medicine faculty and lure more scholars to the city.<sup>102</sup> However, the creation of a botanic garden requires considerable financial support, even more if there is not a backing figure with a solid social web of relations within the horticultural and botanical circles. Thus, the solution came three years later, with the appointment of Carolus Clusius (1526-1609) as its first prefect. Clusius was a prestigious botanist throughout Europe, he travelled long and was an avid collector. He did bring his own collection to Leiden and received help from his botanic friends. He was able to make more than a thousand varieties of plants coexist in the very small garden of that time.<sup>103</sup>

Clusius' forte was without doubt his rich social network, which included more than 300 epistolary contacts and would overcome boundaries of age, gender, social class and nationality.

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<sup>100</sup> NIJMAN. 1994. *The VOC and the expansion of the world-system 1602–1799*. p.225

<sup>101</sup> NIJMAN. 1994. *The VOC and the expansion of the world-system 1602–1799*. p.218-219

<sup>102</sup> Hortus botanicus Leiden. (Visited last 14.01.2023). *The Hortus, History*. <https://hortusleiden.nl/en/the-hortus/history>

<sup>103</sup> Hortus botanicus Leiden. (Visited last 14.01.2023). *The Hortus, History*.

Investigations on the field, explorations and publications were not enough for a naturalist of that time, unless you had a network to share it with, not only for personal affirmation, but also for confrontation and support. He stressed in his letters how these relations were of friendship, even if with mutual benefits of course. This virtual network was a community of people interested, each for their own motives, in botany. Through this web, Clusius built up an incredible collection of plants, seeds, data and observations, and he would also be a generous benefactor with his contacts.<sup>104</sup>

It is actually through friendship that he inherited a big part of his collection of tulips; the Flemish ambassador Ogier Ghislain de Busbecq (1522-1592) donated them to him after his travels in Turkey, where he fell in love with these bulbous plants.<sup>105</sup>

From his epistolary records we are also reminded of plant thieves: often seeds or bulbs that were to be sent would not arrive, or only partially, but even whole plants could be stolen from private gardens, as it happened to Clusius.<sup>106</sup> The need of enclosing gardens for preventing robberies is not new, indeed it is as old as gardens themselves, even before mediaeval times. However, what is relevant in this period is the fact that ornamental plants were more and more an ambitious target. Indicating how even plants that were simply aesthetically pleasing, had great commercial value among the horticultural designing business. The rarest the better, especially for rich merchants and noble elites. It is reported that in the 17th century the market for ornamental and flowering plants reached the extension of that of fruits and vegetables.<sup>107</sup>

It might sound ironic, but it is indeed due to this phenomenon of plant burglary and the fashion of the time that the Netherlands would become known as “the tulip country”. Clusius is said to have had the most beautiful collection of tulip varieties in Europe at the time, and he became so famous for it that many would go visit him to admire the blossoming flowers. Eventually they became a trend in those years and, thus, the thieves started to pay some visits to his garden or to intercept his letters of exchange with other botanists. Although originally native

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<sup>104</sup> F. EGMOND. 2007. *Clusius and friends: Cultures of exchange in the circles of European naturalists*. Carolus Clusius: Towards a cultural history of a Renaissance naturalist, Amsterdam: Editio-Royal Netherlands Academy of Arts and Sciences, 9-48. p.36-38

<sup>105</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.130

<sup>106</sup> EGMOND. 2007. *Clusius and friends*. p.42

<sup>107</sup> Michael LESLIE, John D. HUNT. 2013. *A Cultural History of Gardens in the Age of Enlightenment*. A Cultural History of Gardens: Vol.4. Bloomsbury. p.79

to the Middle East, in Holland tulips spread even through lower social classes becoming a true cultural phenomenon that survived through time until today.<sup>108</sup>

Before departing from Leiden and Clusius, there is one last important element that shows the bond of botanical research and commerce. Clusius is probably one of the first individuals to understand the potential of a company such as the VOC, with international bases and interests spread through every corner of the globe, for naturalists research. In fact, right after its foundation, he contacted the company director Dirck van Os sending a memorandum in which he asks physicians and doctors on board of the Company's ships to collect plant materials and explains the procedures to do it. Even if the results did not arrive during Clusius' time, he anticipated what would soon become a common practice required to all doctors serving the VOC.<sup>109</sup>

This economic and scientific role will become more and more inseparable during the 17th century, especially in the botanic garden of Amsterdam.

As we have seen, Amsterdam was an important economic centre, which grew in importance since the birth of the stock market and the VOC. However, the city was showing the early downsides of urbanization: overpopulation and low health conditions. This results evident in the several outbreaks of plague that killed thousands of people during the 17th century. Thus, the botanic garden, called *hortus medicus*, was a municipal infrastructure created in 1638 with the intent of promoting instruction for apothecaries and diffusion of medicinal remedies to contrast the health crisis, even if ornamental exotic plants started appearing not too long after.<sup>110</sup>

This garden had a hard life in its early days, probably due to the raging plague, and moved several times also to welcome a greater number of plants. It was placed in its current position in 1682 and its core objectives changed profoundly thanks to two figures appointed by the governor: Jan Commelin and Joan Huydecoper van Maarsseveen. Both representatives of the new rich merchant class, they were true business men; Commelin enriched himself by selling pharmaceutical products and Huydecoper was one of the main investors of the VOC. This change of perspective affected the botanic garden by turning it into a growing business for acclimating and redistributing exotic plants, whether useful commodities or decorative.<sup>111</sup>

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<sup>108</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.132

<sup>109</sup> P. BAAS. 2017. *The golden age of Dutch colonial botany and its impact on garden and herbarium collections*. Tropical plant collections: Legacies from the past, 53-62. p.54

<sup>110</sup> K. FREDIANI. 2009. *De Hortus Botanicus Amsterdam*. *Sibbaldia: The International Journal of Botanic Garden Horticulture*, (7): 121-138. p.124

<sup>111</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.168-169



For example, among the important ornamental plants, widely common in Europe today, that reached Amsterdam thanks to the VOC ships returning from South Africa we can find the scented geranium (*Pelargonium*), the clivia, the African lily (*Agapanthus*) and the gerbera.<sup>112</sup>

South Africa was a very important strategic point for the Dutch Company as a supply base before venturing towards Asian oceanic routes. Indeed, it was at Cape of Good Hope that one of the first colonial gardens was ever created in 1652. The Dutch were not focused on imperial territorial expansion as much as other European forces, however, they realized the importance of having stable supply points around the continents for ensuring smooth commercial and military naval activities. For this reason, at first the garden in Cape was mainly dedicated to growing vegetables and fruits for the food supply of the VOC's expedition ships; however, soon they started using it to study and grow exotic plants of interest.<sup>113</sup>

Always keeping in mind the necessities of implementing medical knowledge at home and abroad, the Dutch left us useful records of the traditional knowledge of local ethnic groups that they studied wherever they had the chance. In particular, there are records of early studies on the Khoi and San African populations in Cape, which could be compared to modern studies of ethnobotany and ethnopharmacology.<sup>114</sup>

However, the most profitable plants were those useful for commercial goods, such as palm (for oil), coffee, ananas or guava, of which the Dutch are proud plantation initiators.<sup>115</sup>

It is attributed to the Dutch, and in particular to the Amsterdam botanic garden, the birth of the coffee plantation business. They started coffee plantations in Ceylon (1659) and Java (1696) with specimens retrieved in India. One of these plants from Java reached the garden of Amsterdam in 1706 and, after scientific analysis and experimentation, it is said that from this selected variety, whose seeds were shared with other botanic gardens, most of the coffee plantations of the New World are descended.<sup>116</sup>

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<sup>112</sup> De Hortus. Hortus Botanicus Amsterdam. The Garden, Key Collections. (Last access 30/01/2023). <https://www.dehortus.nl/en/the-garden/key-collections/>

<sup>113</sup> J.G. BRAND 2016. *A Short History of the Company's Garden, Cape Town*. The Heritage Portal. <https://www.theheritageportal.co.za/article/short-history-companys-garden-cape-town>

<sup>114</sup> G. SCOTT, M. L. HEWETT. 2008. *Pioneers in ethnopharmacology: the Dutch East India Company (VOC) at the Cape from 1650 to 1800*. *Journal of ethnopharmacology*, 115(3), 339-360. p.339

<sup>115</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.170

<sup>116</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p.51

The topic of the plantation economy, by some considered as both the cause and the result of European expansion,<sup>117</sup> is the radicalization of a simplified view of the world that spread during the enlightenment: men guided by science and reason were convinced that once natural elements were fully understood, they could be bent and ordered according to human needs. At times, this reasoning was also connected to social phenomena. For instance, in this same era, the Atlantic slave trade was becoming fully developed; while in Asia the labour force was abundant, the Americas were lacking a consistent working force which was a necessary piece for the functioning of the plantation economy.<sup>118</sup>

The fact that plantations were created in far distant lands from Europe does not mean that botanic gardens were not involved. Actually, the contribution of research institutes was a major driver in the establishment of more productive agribusinesses, especially in the case of the Royal Botanic Gardens for the British Empire, as it will be addressed afterwards.

Moreover, the botanic garden of Amsterdam was the inspiring environment for the missing piece that accelerated exponentially the emancipation and evolution of botany as a discipline, as well as an economic business: Carl von Linné (1707-1778). Also known as Linnaeus, he was a Swedish student who became an assistant of Johannes Burman, the director of the Amsterdam botanic garden in 1735.<sup>119</sup>

Inspired by the botanical collections and the knowledge that was accumulating in these acclimating institutes of the Netherlands, Linnaeus published, within few years, two important works including his theory on the sexual system of plants, *Systema naturae* (1735) and *Genera plantarum* (1737). These essays are a strong base for his later work *Species plantarum*, published in 1753, which is considered among the most important texts ever published on taxonomy.<sup>120</sup> Through such work he exposed to the world the binomial system, a methodology for nomenclature that even though it is now more than two centuries old, it still influences modern science.

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<sup>117</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p.46

<sup>118</sup> Igor JOSIPOVIĆ, Marko VUJEVA. 2021. *Economic Aspects of Slavery in the Triangular Trade in the Early Modern Period*. Gazi Akademik Bakış, 14(28): 179–197. p.180

<sup>119</sup> FOGLIATO. 2021. *Orti delle Meraviglie*. p.192

<sup>120</sup> Michael LESLIE, John D. HUNT. 2013. *A Cultural History of Gardens in the Age of Enlightenment*. A Cultural History of Gardens: Vol.4. Bloomsbury. p.86-87

The binomial system represented an accelerating force because it offered a universal language to classify plants.<sup>121</sup> It was simple and applicable to any new and old specimen retrieved, giving a common ground for people from all over the globe to talk of natural species, reducing time consuming translations and misunderstandings. Whether for scientific and medical research or for plant hunters, collectors and horticulturists, the binomial system gradually spread for its efficiency, no matter the opposing opinions of other scholars.

During his travels in European cities, Linnaeus received more than mere scientific inspiration; he was convinced that he could use his botanical knowledge to change the destiny of his home country. Most European countries were dependent on foreign products for their latest commodity trends, such as tea, coffee, cocoa and others. And even though oceanic travel was becoming more and more efficient, it was still very costly to import certain products. Linnaeus' dream was to obtain seeds and cuttings of tropical plants and nurse them in Sweden, to create intensive cultivations there and make the Scandinavian nation self-sufficient.<sup>122</sup>

We have to wait for the explorations of Alexander von Humboldt (1769-1859) to understand that earth climatic regions are connected to plant diversity.<sup>123</sup> With his comprehensive measurements of plant geography, it becomes apparent that no matter the technical advances, certain tropical plants will never thrive in the inhospitable regions of Northern Europe.

Linnaeus' failure to grasp this concept prevented him to accept the political economy of the time; however, the British grasped it very well and for this reason they knew that the only way to obtain the resources they needed, and still making a profit out of it, was to have tropical tributaries.

Indeed, from the 18th century on, the United Kingdom was able to gradually build one of the most powerful empires in history, colonizing and exploiting distant lands and people for centuries.

Eventually, the English territorial and human resources supplanted the Dutch dominion that was mostly based on economic gain, but not as much on military force. The competitiveness changed its balance, but these countries still remained interconnected thanks to botanical exchanges. The golden age of the British empire and colonial botany made use of the contribution of many Dutch botanists, as well as their collections and texts. For instance, the

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<sup>121</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Enlightenment*. A Cultural History of Gardens: Vol.4. p.87

<sup>122</sup> D. P. MILLER, P. H. REILL. 1996. *Visions of empire: voyages, botany, and representations of nature*. Cambridge Univ. Press. p.119-126

<sup>123</sup> MILLER, REILL. 1996. *Visions of empire*. p.267

herbaria of Paul Hermann, one of the key scientific explorers of the VOC of the 17th century, were later acquired by Joseph Banks and would eventually become part of the initial components of the collection of the London's Natural History Museum.<sup>124</sup>

Probably the most influential figure that led to this turnover of powers was indeed Joseph Banks (1743-1820), the first manager of the Royal Botanic Gardens of Kew, president of the Royal Society of London between 1778 and 1820, epistolary correspondent of Linnaeus and hundreds of other useful social contacts.<sup>125</sup>

He is considered an entrepreneur more than a botanist, because even though he was a plant enthusiast independently from the utility of the species, he believed that science, and botany in particular, could bring much benefit to the nation.<sup>126</sup> It was him, who conceived the idea to establish a network of colonial botanic gardens which would serve as bases for plant hunting and act as experimental gardens for crops, vegetables and fruits, which might lead to colonial economic development. And so it became, especially in the century after his death, an extensive net of gardens and stations around the globe, with the Kew Gardens as the reference point at its core.<sup>127</sup>

Some scholars have described this individual as a centre of calculation, applying Bruno Latour's theory to Banks himself. This is due to the fact that Banks, through his social status and his web of relations, not only he could use them to redirect an enormous quantity of data and information to his residence or the Kew Gardens, but was also able to actively select knowledge and use it to ameliorate future explorations and research. He inadvertently created a cycle of accumulation. And all of this would have not been possible without great care and dedication in the organization of his collection.<sup>128</sup>

Other than his close contacts with political and royal figures at home, the exemplification of the wideness of his web is given by the so called Banksian collectors: a group of 126 people spread through Europe and the other continents that might not even ever met Banks in person, but who were cooperating with him through letters and packages of botanical specimens, (they were doctors, captains, plant hunters, botanists, private collectors, etc...)<sup>129</sup>

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<sup>124</sup> BAAS. 2017. *The golden age of Dutch colonial botany and its impact on garden and herbarium collections*. p.60

<sup>125</sup> MILLER, REILL. 1996. *Visions of empire*. p.22

<sup>126</sup> MILLER, REILL. 1996. *Visions of empire*. p.49

<sup>127</sup> Donald P. MCCracken. 1997. *Gardens of Empire. Botanical Institutions of the Victorian British Empire*. Leicester University Press. Preface p.ix

<sup>128</sup> MILLER, REILL. 1996. *Visions of empire*. p.5-32

<sup>129</sup> MILLER, REILL. 1996. *Visions of empire*. p.39-41

As already mentioned, having an important base for operations was key for Banks and, in this process of empowerment of the British Empire, the Royal Botanic Garden of Kew represented the perfect answer and motor of change.

The Royal Botanic Gardens in London were born by the desire of princess Augusta, widow of the prince of Wales, and were designed by the architect William Chambers. Its growth in the collection was mostly due to Banks' supervision from 1771, however the inauguration was in 1759. Its birth arrived much later than that of the oldest gardens in the UK (i.e., Oxford, Edinburgh and Chelsea Physic Garden), yet it was the epitome of the mode of the time: the flourishing landscape gardens.<sup>130</sup>

The 18th century witnessed important changes in society and in garden design to the point that even botanic gardens started adapting to this landscape garden model. The geometrical features of the gardens of previous centuries that were so helpful for physicians and apothecaries to learn about useful plants, start to leave space to more natural disposition of plants. Urban citizens started longing for the picturesque, the less artificial landscapes of the countryside with a nostalgic feeling towards rural life.<sup>131</sup> At the same time, the spread of categorization language, horticultural texts and magazines, and imported exoticisms, were reducing the fear of the wild which was being tamed, and it could be incorporated in garden design.<sup>132</sup>

Moreover, the relevance of taxonomy started prevailing over medical uses. Especially during the 19th century, physicians stopped relying on plants for medical drugs for the latest synthetic products of chemical industries. Eventually the differences in style between botanic gardens and private gardens started reducing, until the only difference was the scientific distribution of plants belonging to the same taxonomic group for distinction and comparison.<sup>133</sup>

On the other side of the world, while exoticism was spreading in the English gardens, also in the colonies landscape transformations were put in place. In particular, Banks was partially involved in the approval of several colonial gardens established during the 18th century, which would gain great importance in the economic business of the British empire later on. Among these, 3 of them were in India.

During this period, most of India's territories were contended by the colonial forces of the Dutch, the French and the English. In 1757 the British managed to obtain the Bengal region and

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<sup>130</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Enlightenment*. p.80

<sup>131</sup> Michael LESLIE, John D. HUNT. 2013. *A Cultural History of Gardens in the Age of Empire*. *A Cultural History of Gardens: Vol.5*. Bloomsbury. p.115

<sup>132</sup> MILLER, REILL. 1996. *Visions of empire*. p.159

<sup>133</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Empire*. p.56-57

push out the other empires.<sup>134</sup> This was the beginning of a long and sad colonial history for India and a flourishing economy for the Europeans. Under the rule of the East India Company the main interest of the colonizers was agricultural revenues, rather than any development of the local infrastructures. Famines were recurrent and no systematic implementation was taken into consideration. Intensive agriculture was the only main activity. Often, the officials sent from Europe would find a terrible reality once landed in this colonial territory. Among them, Lieutenant Colonel Robert Kyd (1746-1793), with the hope to resolve some of the issues, sent a letter back home suggesting the idea of creating a colonial botanic garden. In his mind, this could have helped the introduction and spread of plants in support of the scarcity of food for local populations, other than the future economic benefits of England.<sup>135</sup>

Joseph Banks was among the determining people who were in favor of such an idea, although his concerns were more nationalistic than focused on the wealth of the indigenous. In fact, around 1790, it was approved the creation of 4 botanic gardens distributed in Calcutta, Madras, Bombay and the island of St. Helena. Most of the plants transplanted in these gardens were destined to compete against spice and crop trades against other European empires, especially the Dutch. They were sort of experimental stations for botanical acclimating and studies on the most suitable varieties of crops to grow in these colonies' plantations, for instance cinnamon, coffee and black pepper.<sup>136</sup>

The industrialization process of the 19th century was enhanced by this extractive mentality based on the exploitation of human and non-human resources of the now called Global South while the final benefits were mainly in the European market.<sup>137</sup>

After the death of a charismatic figure such as Banks, there was not a successor that could stand the burden of such an institution as the Kew Gardens and it went under a period of decadence. Yet, its role was not lost; in the Victorian era botany was revived, Kew Gardens became a governmental institution in 1840 after the establishment of the Royal Botanic Society of London (1839), and the botanist William Hooker was the first of a long line of directors that made of Kew the research centre of the world, inheriting the path started by Joseph Banks.<sup>138</sup>

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<sup>134</sup> Z. BABER 2016. *The Plants of Empire: Botanic Gardens, Colonial Power and Botanical Knowledge*. *Journal of Contemporary Asia*, 46(4): 659–679. p.661

<sup>135</sup> BABER. 2016. *The Plants of Empire*. p.666

<sup>136</sup> BABER. 2016. *The Plants of Empire*. p.667-668

<sup>137</sup> Katja Grötzner NEVES. 2020. *Postnormal Conservation*. SUNY series in Environmental Governance: Local-Regional-Global Interactions. p.75

<sup>138</sup> MCCRACKEN. 1997. *Gardens of Empire*. p.74-75

After struggling much in the competition with the French and the Dutch Republic, during the 19th century, the British Empire became the undisputed strongest colonial empire in the world. The Dutch force had already been surpassed and they preferred to ally with the UK instead of succumbing. France tried to be part of the game in trade monopolies, but it went through several political and social transformations in the 18th and 19th century, among which the Napoleonic Wars, which brought much damage to the country, leaving the floor for the British empire to dominate.<sup>139</sup>

The Victorian British empire became so wide that in 1890 it occupied a fifth of the world's lands. Within this context we can see the impressive changes that affected botanic gardens because, when Queen Victoria was crowned (1837), there were around 8 active colonial botanic gardens, while, before the end of her reign in 1901, 30% of all botanic gardens in the world were British (115 out of 378).<sup>140</sup>

To understand what factors influenced this botanic revival, we have to observe the legacy of William Hooker, his understanding of the importance of maintaining public relations, and his organizational skills in managing an educational, scientific and economic institution.

The Royal Botanic Gardens in the home country started to hold educational programs on horticulture and botany at a professional level, raising the standards of botanical knowledge of the nation and creating proselytes to spread their values in colonies.<sup>141</sup>

On the other hand, even if colonial gardens might have started as stations for the EIC's collection and storage of tropical plants, they gradually increased in relevance by becoming experimentation stations.<sup>142</sup> When Hooker took the guidance of Kew, useful plants were propagated in the main greenhouses, studied and sometimes improved. After that, they would be sent out to the colonial gardens to see if they could suit the colony's climate and, in the end, distributed on a larger scale. Hooker, as well as his son after him, carried out several projects of the sort including experimentation on tea, mahogany, papyrus, cork oaks, tobacco, cinchona and Liberian coffee.<sup>143</sup>

Among the actions that contributed to the building up of scientific respectability around the Kew Gardens was the creation of the Kew Bulletin publication in 1887 by the son of William,

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<sup>139</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p.50

<sup>140</sup> MCCracken. 1997. *Gardens of Empire*. p.17-19

<sup>141</sup> MCCracken. 1997. *Gardens of Empire*. p.79

<sup>142</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p. 75

<sup>143</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p. 85

Joseph Hooker.<sup>144</sup> It was meant to increase the communication of updates between the core and the far ends of the Royal gardens, helping the colonies.

While Kew and other Royal Botanic Gardens in the UK were publishing masterpieces and accumulating knowledge, data, specimens and fundings, the gardens in the colonies were constantly struggling for more financial resources and competent staff. They were dependent on the mother country for directives and personnel.<sup>145</sup> For example, colonial gardens were considered officially independent entities, under the rule of colonial governors, yet the word of a director of Kew would be decisive for naming curators and research plans abroad.<sup>146</sup>

One more aspect not to be underestimated is the civilizing ideology that insinuated in these colonial gardens. Such gardens could either be a familiar environment, as public parks for colonizers, or an emblem of modern values to impress on the indigenous populations.<sup>147</sup>

In parallel, in this generation, techno scientific advancements were key in speeding up all other processes. The steam engines were propelling ships, metals were substituting wood for modern engineering projects, glass was being modeled as sheets and bent to create impressive conservatories<sup>148</sup> and finally, the transport of living plants became facilitated by the Wardian case. The Wardian case dates back to 1829, when the physician Nathaniel Ward accidentally created the first terrarium while observing some moths in glass jars. Not even Ward would have believed that thanks to the portable greenhouses, the EIC could transport to Kew for Hooker more than 6 times the amount of specimens that would have been transported over a decade in the previous century.<sup>149</sup>

With regard to the economical contributions of botanic research for the good of the empire, we can count several relevant successes connected to political decisions. For instance, the Chinese empire was holding hard to its monopoly on tea, but eventually was defeated with the opium mass produced in Indian plantations by the British.<sup>150</sup> The export bans of South American countries on cinchona plants were deflected by a few EIC's recruited individuals, who managed to

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<sup>144</sup> MCCracken. 1997. *Gardens of Empire*. p.23

<sup>145</sup> MCCracken. 1997. *Gardens of Empire*. 146-147

<sup>146</sup> NEVES. 2020. *Postnormal Conservation*. p.74

<sup>147</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Empire*. p.7-8

<sup>148</sup> MCCracken. 1997. *Gardens of Empire*. 119

<sup>149</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p. 86

<sup>150</sup> BABER. 2016. *The Plants of Empire*. p.669



retrieve specimens illegally and bring them to Europe.<sup>151</sup> With the intensive cultivation of cinchona trees it was possible to obtain much larger quantities of quinine (used to counteract malaria symptoms) and incentivize deeper military excursions in other foreign lands, especially in the African continent.<sup>152</sup>

Indeed, the British Empire seemed unstoppable in the 19th century, and many victories were connected to plant trades and horticultural experimentation. Nevertheless, the Victorian reign was not meant to last forever, just as the role of Kew Gardens, which saw a decline from the 1890's, because the importance given to natural science, and thus botany, was dissipating. In the end, botanic gardens were destined to be considered comparable to relics of a great past.<sup>153</sup> With the beginning of the 20th century we enter a new era, slowly reaching what is today defined as the Anthropocene.

### 1.3 Modernity

Looking back at the previous centuries, what is today known as the epoch of the great travelers became consolidated in the collective imagination of western cultures as an euphoric and adventurous run to explore the unknown. However, this imaginary picture hides a terrible truth: the seeds of empires, colonization, global slavery trades, plantations and a modern globalized economy in a fractured world divided in exploited and exploiters.

Within this context, botanic gardens had their role turned upside down, from research institutions to business centers. They were places of discovery as well as appropriation, transformation and redefinition of plants, knowledge, language and, indirectly, even people and societies. Until the 20th century began and the equilibrium of the world started changing again.

Slowly all the world's unknown lands were explored, the maps filled (when the expeditions reached even the poles), and the arrival of the new century involved some of the fastest and most important changes of human history and, with them, new problems arose.

The same factors that made Great Britain the global leader would eventually result in its disintegration; the costs of maintaining a vast dislocated colonial empire were enormous<sup>154</sup> and they could only be outweighed by the national industrial production, in particular that applied to military assets. But, eventually, the competition in this sector among European powers increased

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<sup>151</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p.113

<sup>152</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p.127

<sup>153</sup> MCCracken. 1997. *Gardens of Empire*. p.209

<sup>154</sup> ARRIGHI, SILVER. 2006. *Caos e Governo del Mondo*. p.96

to a critical point. The arms race opened up the way for private multinational companies, many of which located in the US and, when the World Wars exploded, this was the tipping point that led the United States to enrich at the expense of Europe and to become the new financial and military superpower of the globe.<sup>155</sup>

Techno-scientific development, merged with political discourses, is constantly used to redefine the authority pyramid of the globe. Global conflicts changed everything: the age of empire fell and left space to a new equilibrium based on nation-states and military power.

In this period, political discourses and new ideologies were the new main concern of societies, within which, social classes were being challenged. Plus, although slavery had been formally abolished in the previous century, only then the chance to revolutionize the imperial system arrived. Thus, in almost all colonies a wave of indigenous nationalism was spreading.<sup>156</sup> These social movements started a chain of events that took place all over the globe, resulting in the decolonization process which continued during the whole century.

As it can be easily imagined, such historical events did influence the world of botanic gardens as well. At the turn of the century, and especially after the World Wars, natural sciences were not as relevant as before, there was no time left for botanic gardens anymore. In particular, the WWII had a terrible direct impact on botanic gardens that, far from being considered a basic necessity, were abandoned, uncared for, raided at times, or even destroyed in the worst cases. One example is the herbarium of the Berlin Botanic Garden, bombed in March 1943 along with the library, which represented a loss of 175 years of botanical collections.<sup>157</sup> Looking at Italy the situation was especially dramatic. When the military front crossed Florence, the botanic garden was used to bury war victims;<sup>158</sup> the garden of Naples was completely devastated by bombings and basic needs: the iron gates were melted down for military purposes, many people found refuge in the garden buildings and used the flower beds for cultivating vegetables and basic crops to counteract shortages in food rations and, last but not least, when the anglo-american soldiers occupied the city (1944-1945), half the land was turned into a military drill camp and the rest was used as football pitch.<sup>159</sup>

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<sup>155</sup> ARRIGHI, SILVER. 2006. *Caos e Governo del Mondo*. p.79-84

<sup>156</sup> MCCRACKEN. 1997. *Gardens of Empire*. p.210

<sup>157</sup> E. D. MERRILL. 1943. *Destruction of the Berlin Herbarium*. *Science*, 98(2553): 490–491. <http://www.jstor.org/stable/1669618>

<sup>158</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.65

<sup>159</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.89

Contrary to appearances, private gardening was indeed promoted by governments, but certainly not for the sake of discovery as in the previous century. Within a warlike and economic depression context, the idea of allotment gardens and victory gardens emerged as a way to help on the national front to support self-sufficiency.<sup>160</sup> Propagandistic messages, of which Judith Sumner talks in her book *Plants go to war*, were common especially in the US, but not only, and they were saying: “cultivate for your nation”.<sup>161</sup>

Regarding the imperial colonies, the rebellion against the governments imposed by European settlers was carried also against other sorts of institutions, like colonial botanic gardens. Many gardens did not survive through the 20th century, but those that did were transformed and turned into public parks or national botanic gardens of newly independent states.<sup>162</sup>

One example is the Garden created by the VOC three centuries earlier in Cape Town, South Africa, which became a public park, now known as Kirstenbosch Botanic Gardens. In the year 1964 it was declared National Monument and, even if it was once involved in botany and education, its only remaining role is to represent a place of amusement and relaxation for the citizens.<sup>163</sup> In a different continent, Australia obtained its independence from Britain quite late, in the 1960's, but it revealed to be a great opportunity for rebirth. In order to break free from the British influence and find its own identity, the country moved its attention towards local species and indigenous knowledge. The creation in 1965 of the indigenous botanic garden in Perth and, in 1967, the Canberra Botanic gardens are only two of the most relevant examples of institutions that supported Australia's path in becoming a global leader on indigenous studies in connection with environmental conservation.<sup>164</sup>

These events were in a way anticipatory and supporting of the environmental movements wave that took place in the 1970s.

This movement is a counter-effect to the dangers of natural exploitation that became apparent in this decade and was the cause of tremendous cases of pollution and health hazards. The realization that nature should be preserved in the same ways as social rights starts insinuating in the western societies. Thus, the spread of international organizations, led first and foremost by

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<sup>160</sup> John D. HUNT. 2013. *A Cultural History of Garden in the Modern Age*. A Cultural History of Gardens: Vol.6. Bloomsbury. p.77

<sup>161</sup> Judith SUMNER. 2019. *Plants Go to War. A Botanical History of WWII*. McFarland, Incorporated, Publishers.

<sup>162</sup> MCCRACKEN. 1997. *Gardens of Empire*. p.210

<sup>163</sup> BRAND. 2016. *A Short History of the Company's Garden, Cape Town*. The Heritage Portal.

<sup>164</sup> Brett M. BENNETT. 2018. *How the colonial past of botanical gardens can be put to good use*. The Conversation. <https://theconversation.com/how-the-colonial-past-of-botanical-gardens-can-be-put-to-good-use-104786>

the United Nations, would slowly touch environmental issues as well. Botanic gardens have once again the opportunity to transform their role to regain political relevance.

Here will be presented the series of steps in the road of plant conservation that proceeded in parallel with the refinement of botanic gardens into modern conservation institutions.

Health concerns connected to environmental issues are not recent, they were already known in the past. For instance, back in the Victorian age, deforestation, and thus soil loss, was thought to cause lesser rainfalls and topo-geographical changes. Indeed, tree planting was promoted even in some colonies to make urban areas healthier and aesthetically pleasing.<sup>165</sup> Some botanic gardens in the colonies even warned about the danger of large monocultures and tried to promote a better differentiation of crops, although with little success.<sup>166</sup>

The innovation in the 20th century was the beginning of concern for the environment per se, other than in correlation to human health. And in this context, since the 1920s, botanic gardens have tried to present themselves in the role of conservation institutions, taking advantage of the collections accumulated in the past and adjusting their public declared values. In fact, during the International Congress for Nature Protection that took place in Paris (1923), it was officially declared how botanic gardens should preserve species in danger of extinction.<sup>167</sup>

However, we have to wait until the second half of the century for seeing global waves of environmentalism movements among the masses, mainly during the 1970s and 1990s.

This is due to the fact that those who knew the potential dangers of pollution and environmental degradation were uncoordinated and did not have a large consensus among communities. Many environmental aspects were overlooked in the period of recovery after the global conflicts and the cold war, because the economic boom was so great that western societies thought it could last forever. Obviously, this was not the case.

One of the first research groups that focused on this topic and gave birth in a way to the sustainability discourse is the Club of Rome, which published in 1972 the Limits to Growth report. The report highlighted the incompatibility of economic and demographic growth with the finite resources that our planet offers.<sup>168</sup> Seeing the earth more as a unit was also a direct consequence

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<sup>165</sup> MCCracken. 1997. *Gardens of Empire*. p.142

<sup>166</sup> MCCracken. 1997. *Gardens of Empire*. p.133

<sup>167</sup> V. H. HEYWOOD. 2017. *The future of plant conservation and the role of botanic gardens*. *Plant Diversity*, 39(6): 309-313. p.312.

<sup>168</sup> Daniele BROMBAL. 2015. *La sfida della sostenibilità in Cina*. *Orizzonte Cina*, 6(3): 1-16. p.3

of the space expeditions that allowed the world to observe the planet from the outside for the first time in history in 1969.<sup>169</sup> From this event, the Earth Day celebration was born a year after.

In the years that followed, many grass-root movements spawned around Europe, but especially in the US, and their objective was openly to preserve natural lands, ask for more legal action in function of a safer environment and to demand for these provisions to actually enter into force. Some examples of their success are the Endangered Species Act (1973) and the Toxic Substances Control Act (1976).<sup>170</sup>

As previously mentioned, some tremendous episodes of pollution were also a relevant contribution for the environmental conscience to spread. The case of the Love Canal (1979) is one of the most famous in the history of the US cases of chemical industrial pollution of an area, which was covered up and sold for construction. The damages to the soil, the environment and the people who moved in the newly built area were devastating.<sup>171</sup>

The mistrust in industrial production and chemical products spread much faster after episodes such as this and thanks to scientists that were trying to warn society of these dangers, like Rachel Carson with her *Silent Spring*.<sup>172</sup> Carson is considered a role model in modern studies of Environmental Humanities because with her literary work she exemplified the importance of finding better ways of communication for scientists and researchers in order to reach a collective conscience with their findings.

Together with international organizations and conferences, all these factors led to one of the biggest public manifestations in history with the 20th anniversary of Earth Day in 1990,<sup>173</sup> resembling much to today's Fridays for Future global protests.

Nonetheless, we cannot forget that our focus should remain on plant conservation, which can require some special attention that general environmental protection does not always consider.

In fact, even though the environment was under public spotlight, plants were a bit underestimated in comparison with animals. In recent times it has been studied the human

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<sup>169</sup> BROMBAL. 2015. *La sfida della sostenibilità in Cina*. p.3

<sup>170</sup> R. CAHN, P. CAHN. 1990. *Did Earth Day Change the World?*. Environment: Science and Policy for Sustainable Development, 32(7): 16-43. p.19

<sup>171</sup> E. C. BECK. 1979. *The love canal tragedy*. EPA JOURNAL, 5, 17.

<sup>172</sup> Rachel CARSON. 1999. *Primavera silenziosa*, (Silent Spring). Translation by Gastecchi Carlo Alberto. 6th ed. Milano Feltrinelli.

<sup>173</sup> CAHN, CAHN. 1990. *Did Earth Day Change the World?*. p.17

tendency to notice or give more value to animals than plants under the name of *plant blindness* and it has been declared the danger of this phenomenon posed to conservation efforts.<sup>174</sup>

For this reason, in the 1980s the IUCN (International Union for Conservation of Nature) and WWF (World Wildlife Fund) launched a specific Plant Conservation Programme.<sup>175</sup> An indirect consequence of this provision was the establishment of other initiatives and organizations specifically concerned with the flora, out of which the Botanic Garden Conservation Secretariat (today called Botanic Garden Conservation International, BGCI) is without doubt the most prominent. Founded in 1987, BGCI is a non profit organization based in the UK which today has more than a hundred members composed of botanic gardens from all over the globe and its goal is to “mobilize botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet”.<sup>176</sup>

Within the larger framework for plant conservation, the adoption of the Convention of Biological Diversity (CBD) in 1992 at the Earth Summit in Rio de Janeiro<sup>177</sup> was fundamental because, under the UN umbrella, biodiversity protection matters could reach a larger public, almost all nations’ governments in the world. It was during the sixth Conference of the Parties (COP6) of the CBD in 2002, after the push of the Gran Canaria Declaration (2000), that it was finally elaborated a Global Strategy for Plant Conservation (GSPC).<sup>178</sup> This strategy was composed of 16 objectives to be achieved within 2010 and offered a guideline for all the parties involved on how to implement this strategy at the national level, and botanic gardens were a considerable partner in many of the implementation processes.<sup>179</sup> Naturally, the objectives were ambitious and it would take longer than a decade to achieve, yet the Strategy demonstrated some effectiveness; thus, in 2010 at the tenth COP of the CBD it was agreed to sign a second edition of the GSPC with final completion by 2020.<sup>180</sup> The multiple facets of botanic gardens are the main reason for which

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<sup>174</sup> M. BALDING, K. WILLIAMS. 2016. *Plant Blindness and The Implications for Plant Conservation*. Conservation Biology, Volume 30(6): 1192–1199. p.1193

<sup>175</sup> O. HAMANN 1985. *The IUCN/WWF Plants Conservation Programme 1984-85*. Vegetatio, 147-149.

<sup>176</sup> BGCI. (Last visited 16/02/2023). About BGCI, Our Organization and Strategy. <https://www.bgci.org/about/about-bgci/our-organisation-strategy/>

<sup>177</sup> CBD. (Last visited 16/02/2023). *History of the Convention*. <https://www.cbd.int/history/>

<sup>178</sup> P. W. JACKSON, K. KENNEDY. 2009. *The global strategy for plant conservation: a challenge and opportunity for the international community*. Trends in plant science, 14(11): 578-580. p.578

<sup>179</sup> JACKSON, KENNEDY. 2009. *The global strategy for plant conservation*. p.578 (ibidem)

<sup>180</sup> S. SHARROCK, R. HOFT, B.F.S. DIAS. 2018. *An overview of recent progress in the implementation of the Global Strategy for Plant Conservation: a global perspective*. Rodriguésia 69(4): 1489-1511. p.1489.

they became the right hand of national implementation programmes: they can actively contribute to a dozen of the 16 targets proposed in the global strategy, such as increasing public awareness, carrying out *in situ* and *ex situ* conservation projects and research, implementing digital resources and, especially, forging skilled staff in horticultural techniques and being a connective link between international, national and local institutions.<sup>181</sup>

Naturally, not all botanic gardens have the resources to actively pursue all targets with the same commitment, thus each of them focuses on its own strength to undertake actions in the fields they are more consolidated and, at times, attempt at ameliorating their lows.

There was the CBD's intention to update for the third time the GSPC at the turn of the 2020 decade;<sup>182</sup> however, due to the Covid-19 pandemic, such process was delayed together with many other international meetings and no new version has been approved yet.

#### 1.4 Postmodern conservation

In order to survive and, in a way, to be reborn, botanic gardens managed to become places politically relevant once again, thanks to the wave of interest towards nature conservation and endangered species protection. And the process was helped by the fact that governance is becoming more and more decentralized, allowing non-state actors to gain importance.<sup>183</sup> Quoting Timothy Luke, botanic gardens are still connected to the politics of managing human and non-human lives, exerting a form of bio-power.<sup>184</sup> However, this is not a peculiarity they gained in the last century, it has always been part of their essence. As it should be apparent throughout the whole first chapter, elements of education, governance, political and economic relevance, social functions and symbolism all merge together and combine differently depending on the context, in a similar way as species adapt to niche changes.

Just as it is part of nature to constantly change, even humans and their activities need to be flexible and adapt to changes. And right now, in a postmodern reality, botanic gardens have to

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<sup>181</sup> S. BLACKMORE, M. GIBBY, D. RAE. 2011. *Strengthening the scientific contribution of botanic gardens to the second phase of the Global Strategy for Plant Conservation*. Botanical Journal of the Linnean Society, 166(3): 267-281. p.268-269.

<sup>182</sup> CBD. 2022. *The Development of a Post-2020 Global Strategy for Plant Conservation as a Component of the Global Biodiversity Framework*. Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA).

<sup>183</sup> NEVES. 2020. *Postnormal Conservation*. p.62

<sup>184</sup> T. W. LUKE. 2000. *The Missouri botanical garden: Reworking biopower as florapower*. Organization & environment, 13(3): 305-321. p.314

come to terms with an epoch rich in complexities that wants to become fully conscious of itself, the Anthropocene. This equals the opportunity to evolve again into something new and, especially for institutions of historical relevance, to overcome their colonial past as well as an unpredictable future.

Indeed, climate change and social (as well as environmental) justice are now the latest elements that botanic gardens have to deal with in the 21st century.

In practice, this translated into actions towards the promotion of sustainable actions both outside and inside gardens, like the introduction of renewable energy plants to offset the carbon footprint of a botanic garden (Phipps Conservatory and Botanical Gardens, USA),<sup>185</sup> or the amelioration of the management of waste waters (Auckland Botanic Garden, New Zealand).<sup>186</sup> On the side of social matters, several gardens are today focused on the intertwined relation between humans and plants, such as the Amy B.H. Greenwell Ethnobotanical Garden, whose mission is to support the local Hawaiian traditions;<sup>187</sup> many others also promote activities to teach people how to get close to plants for their daily activities again (i.e. Jardin Botanico of Puebla, Mexico)<sup>188</sup> or activities in support of eco-citizenship (Kew Gardens, UK).<sup>189</sup>

Moreover, the actions that were once dedicated to collection and research for the benefits of nations and empires are now carried out in seed banks theoretically for the benefit of biodiversity conservation (Millennium Seed Bank)<sup>190</sup> or for the benefit of global food supply (Svalbard Global Seed Bank).<sup>191</sup>

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<sup>185</sup> BGCI. 2020. BGCI Technical Review. The role of botanic gardens in practising and promoting environmental sustainability. p.19

<sup>186</sup> BGCI. 2020. BGCI Technical Review. The role of botanic gardens in practising and promoting environmental sustainability. p.9

<sup>187</sup> Amy B.H. Greenwell Ethnobotanical Garden. (Last visit 18/02/2023). *The Garden*. <https://www.amygreenwell.garden/the-garden/>

<sup>188</sup> NEVES. 2020. *Postnormal Conservation*. p.50

<sup>189</sup> NEVES. 2020. *Postnormal Conservation*. p.102

<sup>190</sup> RBG Kew. (Last visit 19/02/2023). *Millennium Seed Bank*. <https://www.kew.org/wakehurst/whats-at-wakehurst/millennium-seed-bank> . *The Millennium Seed Bank hides an underground collection of over 2.4 billion seeds from around the world, banking them to conserve them for the future.*

<sup>191</sup> Crop Trust. (Last visit 19/02/2023). *Svalbard Global Seed Vault, Mission*. <https://www.croptrust.org/work/svalbard-global-seed-vault/> . *The Seed Vault safeguards duplicates of 1,194,244 seed samples from almost every country in the world, with room for millions more. Its purpose is to backup genebank collections to secure the foundation of our future food supply.*



However, some relevant social aspects are still overshadowed by the techno-scientific methodology applied in matters of governance of recent years. For instance, seeds, which are also cultural artifacts, have been easily moved, stolen or substituted for centuries without concerns for the effects it can have neither on the country of origin or destination.<sup>192</sup> As Kristina Lyons states in her *Vital Decomposition*, seeds cannot simply be preserved, they “need to be resocialized”,<sup>193</sup> because in most cases local communities are losing contact with their traditional knowledge and once the uses of plants are lost, they cannot be retrieved.

In conclusion, botanic gardens seem determined to persist in the future, always dealing with new perspectives and attempting to move forward thanks to their interdisciplinarity. Yet, interdisciplinarity without coordination might turn into confusion and simple concern for environmental and social issues does not necessarily mean that botanic gardens put such interests first in a fully comprehensive way. Last but not least, the anthropocentric approach still seems utopist to eradicate.

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<sup>192</sup> BROCKWAY. 1979. *Science and Colonial Expansion*. p.35-36

<sup>193</sup> Kristina M. LYONS, 2020 *Vital Decomposition: Soil Practitioners and Life Politics*. Duke University press. p.110

## Chapter 2. Italy and the Botanic Garden of Bergamo

### 2.1 The Italian Context

From global to local, the focus of our discourse will now sharpen towards the sunny Italian peninsula. As it was explained in the previous chapter, it is the official birthplace of botanic gardens, however, since the Renaissance, much has changed and it is very interesting to explore how the global changes did affect the current botanic panorama in Italy.

According to the data gathered for the compilation of the *Action plan for Botanic Gardens in the European Union*, in the year 2000 Italy was one of the European countries with the highest number of botanic gardens (54), after Germany(78), the UK(77) and France(68).<sup>194</sup> And this number has been growing, according to the official list of botanic gardens in Italy.<sup>195</sup>

The considerable number of botanic gardens can be attributed to several ingredients.

First of all, despite the limited physical extension of the country, the varied and complex morphology allows biodiversity to manifest itself in infinite ways from coastal areas to mountain and alpine regions, from valleys and lakes to rocky arid regions, from forests to grasslands. In other words, Italy has a very rich biodiversity and a high level of endemism (species that cannot be found elsewhere).<sup>196</sup> Especially for plants, within the over 8'100 species present in the country, there is a high percentage of plants only native to Italy (20% endemic species).<sup>197</sup>

Another crucial factor is the central position of the country within the Mediterranean sea, a trading point between Europe, Africa and Asia: a land of exchange of cultures, traditions, languages and even biological exchanges since the most ancient times. The human factor cannot be overlooked in understanding the biodiversity of a country. Certainly humans are the reason why some species were preferred over others for agricultural, pharmaceutical or gastronomic reasons, yet societies change as well and this has also indirectly facilitated the genetic variability of species to continuously grow. In particular, the Italian nation only became a unified country in

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<sup>194</sup> BGCI. 2000. *Action Plan for Botanic Gardens in the European Union*. National Botanic Garden of Belgium, Scripta Botanica Belgica, 19. p.7

<sup>195</sup> L'Orto Botanico d'Italia. *Elenco degli orti botanici italiani*. (Last visit 13/03/2023). <http://www.ortobotanicoitalia.it/gli-orti-botanici/>

<sup>196</sup> ISPRA Ambiente. *Come si presenta la situazione della biodiversità in Italia?*. (March 2020). <https://www.isprambiente.gov.it/it/attivita/biodiversita/le-domande-piu-frequenti-sulla-biodiversita/come-si-presenta-la-situazione-della-biodiversita-in-italia>

<sup>197</sup> IUCN, Comitato Italiano. 2020. *Lista Rossa della Flora Italiana. 2 Endemiti e altre specie minacciate*. Ministero dell'Ambiente e della Tutela del Territorio e del Mare. p.10

the last century, we cannot forget that it was influenced in so many ways by the succession of numerous historical phases and cultures from the east to the west, from the sea and over the alps: Greeks, Arabs, Spanish, French, Germanic traditions and much more are vivid traces that juxtaposed themselves over time and left their mark.

The combination of natural and anthropic ingredients is at the origin of the Italian richness and beauty from a biocultural point of view. Thus, it does not surprise that the Italian gardens would reflect it too.

Botanic gardens in Italy are not only numerous, but very distinct one from another. They are fairly homogeneous in their distribution over the regions, with a slight overabundance of institutions in Tuscany and Lombardy.<sup>198</sup>

Some differences regard the foundation period, thus, the reasoning behind them and their structure as well. The most ancient gardens, today considered historical institutions, are the first examples in the world of university institutions with educational and research scopes related to plants. As we have seen, the Gardens of Pisa and Padua are the perfect example.

In particular, the original design of the garden in Pisa included eight sections shaped in squares, recalling the symbolism of the terrestrial element, each with a water element in it, the fountains. At the time the four elements (earth, water, fire and sky) were a recurring aesthetic theme in garden design.<sup>199</sup>

The preferred style was very geometrical and practical, often of limited size, to facilitate demonstrations and confrontation over plants for medicinal use.<sup>200</sup> Since Italy was the first country to publicly create such institutions and, more in general, the specific taste for using regular proportions as essence of beauty (i.e. Villa Aldobrandini at Frascati, Boboli Gardens in Florence), such style eventually spread in Europe from the 1650 until the 1800 and will later be known as the Italian garden style, or formal gardens.<sup>201</sup> Yet, even in later centuries, the low resources of universities and the scientific taxonomic mindset will make the application of such formal style a common trait among university botanic gardens in Italy. It can be seen, for

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<sup>198</sup> L'Orto Botanico d'Italia. *Elenco degli orti botanici italiani*. (Last visit 13/03/2023). <http://www.ortobotanicoitalia.it/gli-orti-botanici/>

<sup>199</sup> L'Orto Botanico d'Italia. Orto Botanico di Pisa. (last visit 08/03/2023). <http://www.ortobotanicoitalia.it/toscana/pisa/>

<sup>200</sup> Marina CLAUSER, Pietro PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. Nuove Direzioni Editore. p.19

<sup>201</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Enlightenment*. p.54

example, at the Botanic Garden of Catania (Sicily),<sup>202</sup> which was founded in 1858 by the professor Francesco Tornabene and still presents simple geometrical flower beds.<sup>203</sup>

During later historical phases, when gardens were gaining relevance all over Europe, especially among royal and imperial governments, the garden style changed as well. The empires were shaping themselves and this went hand in hand with the expression of power through the display of gardens that would have an impact bigger than ever. In practice, it meant for gardens to become much more extensive and to gain a specific perspective; in fact, such style is defined as prospectic gardens (French style). The greatness of gardens was not less in Italy, when in the 17th and 18th century several noble villas were built according to this influence. The most striking example is the garden annexed to the Caserta Residence (1752),<sup>204</sup> with its 3 km length and the fountains centrally placed to guarantee a perfect view of the villa and the park.

Most university botanic gardens do not match this design due to the different purpose of their creation, yet there are exceptions such as the Botanic Garden of the University of Rome,<sup>205</sup> which in 1883 was relocated in the historical property of Villa Corsini and has a remarkable extension of 12 hectares.<sup>206</sup> The palace with the garden belonged for a period to the Queen of Sweden, Christina, who abdicated in 1654 due to her religious conversion to the Catholic church and moved to Rome. Such events contributed to raise the beauty and reputation of the property and, after her death, it was purchased by the Corsini family, which commissioned a renovation of the garden design to the architect Ferdinando Funi. It is thanks to him that the large land acquired the perspective view that is visible even today from the palace.<sup>207</sup>

Moreover, from 1797 to 1813, some Central and Northern regions of Italy were under the direct French rule of Napoleon, who strongly believed in the practical application of enlightened ideals to public works in order to educate society. For this reason, it is during his rule that several public parks, tree-lined avenues and even botanic gardens were planned in Italian cities, (i.e. Milan, Mantova, Venice, Padova, Turin, Lucca and Florence).<sup>208</sup>

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<sup>202</sup> G. BARTOLO, C. BRULLO, S. PULVIRENTI. 2010. *Storia scientifica e assetto attuale dell'Orto siculo dell'Università di Catania*. Bollettino Accademia Gioenia Sci. Nat., 42(372): 135-158. p.136

<sup>203</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.254

<sup>204</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.24

<sup>205</sup> *ibidem*

<sup>206</sup> Università degli Studi di Roma 'La Sapienza'. Il Museo, Notizie Storiche. (Last visit 09/03/2023). <https://web.uniroma1.it/ortobotanico/notizie-storiche/notizie-storiche>

<sup>207</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.72-74

<sup>208</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Empire*. p.3

Finally, around the middle of the 18th century the global power of the English Empire and romanticism would give birth to one of the most appreciated styles in garden design in Europe, which is largely used in the design of botanic gardens nowadays: the English Landscape Garden. Its most appreciated feature is the naturalness appearance that is meant to be achieved, breaking out from past geometrical designs, even though the design remains completely anthropogenic. Nature was becoming known and controlled, thus there was no more fear of it, but fascination.<sup>209</sup>

Landscape gardens' influences resulted perfect for botanic gardens designers for several reasons.

Firstly, it allowed the standardization of exoticism within gardens; during colonialism the theme of taming the wilderness was an extension of ideological power of the empires in distant countries as much as within national borders. The inclusion of exotic elements within botanic gardens might have started for political and economic reasons, but in the 19th century was consolidated all over Europe almost as a fashion trait. Certain elements became almost essential in botanic collections as, for instance, greenhouses specifically dedicated to *Orchidaceae* or ferns and jungle ponds.<sup>210</sup> In fact, they can also be found in several Italian gardens, like the Lily ponds in Padua, in Bergamo or in Palermo.

Secondly, the elimination of physical divisions between plant groups to render the landscape more natural will later be appreciated by the scientific community as well for the opportunity of gardens to reflect a more realistic representation of ecological processes and macro-worlds on a smaller scale. Most modern botanic gardens are planned in this way with the objective to show the visitors the different real life biomes that are present on earth, while offering an amusing view that can be appreciated even by a non-academic public.

For instance, the Botanic Garden of Naples, founded in 1809, has several areas organized on an ecological basis: the desert, the coastal area, the peatland, the rocky area, the mediterranean area and the ponds for aquatic plants.<sup>211</sup>

The Botanic Garden of Bergamo, in particular the section of Città Alta, has a very pleasing visual appearance, which makes the most of its very limited area bringing the visitors in a world diametrically opposite to the urban environment, with no straight lines and no walls. In fact, it was originally created to reproduce alpine gardens according to the personal taste of the founders.

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<sup>209</sup> LESLIE, HUNT. 2013. *A Cultural History of Gardens in the Age of Enlightenment*. p.58-59

<sup>210</sup> MCCracken. 1997. *Gardens of Empire*. p.126

<sup>211</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.184

In connection to the morphological variability of the Italian peninsula mentioned previously, although they all promote values of ecological consciousness and biodiversity protection, several botanic gardens were developed with the scope of preserving species belonging to a specific environmental niche, such as alpine botanic gardens. The approach of focusing on native flora is considered more modern and we can find some examples in the Valle D'Aosta region, where there is a higher percentage of endemic relevant species compared to the national average.<sup>212</sup>

One of these is the Paradisia Alpine Garden, situated within the Gran Paradiso National Park, which was founded in 1955 to increase awareness on the specific flora of this natural area and presents more than a thousand different species. In representation of the beautiful alpine biodiversity, the name of the garden is dedicated to a native specimen, *Paradisea liliastrum* (a white lily).<sup>213</sup>

Differences do not end to the collections hosted within gardens: nowadays they can be categorized according to their management (public or private institutions), whether they are connected to a University or not, and their thematic specialization. At the moment, the Italian Botanical Society (SBI) accounts for 76 entities within the working group of Botanic Gardens and Historical parks of Italy, out of which 31 belong to Universities, while the rest is managed privately or by other regional and local administrations.<sup>214</sup>

Depending on the fundings' origin, resources are not equal for all botanic gardens, thus the activities carried out in gardens vary greatly, just as the staff composition and the targets.

And that is the reason why most gardens prefer to dedicate themselves mostly to one thematic role over the others, either education, scientific research, social contribution, or touristic attraction. It is rare for an institution to be able to actively support actions in all these directions, since it requires consistent funding, a modern infrastructure and a wide pool of prepared personnel.

The most praised garden in this sense in Italy is without doubt the Botanic Garden of Padua, which has also been nominated a UNESCO World Heritage Site in 1997 for its contribution in the historical progress of several scientific disciplines, like botany, medicine, chemistry, ecology and pharmacy.<sup>215</sup> The centennial experience and tradition in botanical research not only has been

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<sup>212</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.66-67

<sup>213</sup> Parco Nazionale Gran Paradiso. Giardino Botanico Paradisia. (Last visit 13/03/2023). <https://www.pngp.it/visita-il-parco/giardino-botanico-alpino-paradisia>

<sup>214</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.30

<sup>215</sup> OrtoBotanico di Padova. L'Orto nel Patrimonio UNESCO. (last visit 15/03/2023). <https://www.ortobotanicopd.it/it/lorto-nel-patrimonio-unesco>

preserved over the ages, but it has been renewed as well, making the Paduan garden one of the most avant-garde in the country, in Europe and in the world. The current investments in modern and more sustainable infrastructure are visible in the Biodiversity Garden, an expositive collection of plants from all over the globe divided by climatic conditions inside a solar active building.<sup>216</sup> The energy efficiency of the building is maximized by the materials and their use. For example, the levels of humidity within the rooms are balanced by the outdoor pool of the garden, which acts as a reservoir and it is mainly dependent on rainwater. The electricity for the functioning of the greenhouse is derived from the solar panels installed on the roof. Each room condition is determined by the plants' stimuli which are detected by a smart interactive system. And the materials used for the glass is actually a plastic derivative, less likely to get corroded by time and the sun, and which is designed to reduce heat dispersion.<sup>217</sup>

Certainly a long historical tradition can be of help in supporting the reputation of an institution and to obtain investments, yet it is not an assurance for success. The case of Castel Trauttmansdorff, in Trentino Alto Adige, is the perfect example of a very young but successful venture.<sup>218</sup> Within only a decade since its inauguration in 2001, the Gardens of Trauttmansdorff accumulated a series of awards that places this institution at the top of the ladder in the sector of Garden Tourism. Starting with the prize as “Most Beautiful Garden of Italy” in 2005, it came in 6th at the European garden competition, and in 2013 it was finally recognized as “International Garden of the Year”. It is noteworthy the fact that no matter the accomplishments, the managers of the garden never ceased to always push the bar higher, differentiating their activities and attractions. In fact, in 2021, the project “Diversity” carried out at Trauttmansdorff was awarded by the European Ecological Gardening for the promotion of biodiversity.<sup>219</sup>

Indeed, tourism does have a primary role not only in the economy of Italy, but in the economy of botanical institutions as well. All botanic gardens have, in a way or another, aesthetic and amusement among their main objectives in order to raise fundings which is unfortunately very limited in most cases, especially for public gardens in Italy.

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<sup>216</sup> VIOLA, SPECIALE. 2021. *Andare per Orti Botanici*. p.21-22

<sup>217</sup> OrtoBotanico di Padova. Solar active building. (last visit 15/03/2023). <https://www.ortobotanicopd.it/en/solar-active-building>

<sup>218</sup> Trauttmansdorff. La Nascita dei Giardini, Una retrospettiva storica. (last visit 15/03/2023). <https://www.trauttmansdorff.it/it/i-giardini/retrospettiva-storica/storia-dei-giardini.html>

<sup>219</sup> Trauttmansdorff. Riconoscimenti. (Last visit 15/03/2023). <https://www.trauttmansdorff.it/it/i-giardini/riconoscimenti.html>

For instance, tourist revenues at times can be of great help in the implementation of research projects and infrastructures, which in modern times are becoming more and more a priority. The adaptation to research stations is spreading in most gardens, whose collaboration with seed banks, propagation nurseries and modern laboratories is crucial for biodiversity conservation efforts.

One of the Italian institutions most concerned about research is the Botanic Garden of Turin.

In collaboration with the Scientific department of the University, the Botanic Garden carried out several projects for the preservation of the flora. Among the activities carried out we can recall some investigations on pollen sedimentations, actual *in situ* and *ex situ* conservation actions of hydrophilic local species (i.e. *Isöetes malinverniana*), and the recovery of numerous ancient fruit plant varieties.<sup>220</sup>

Another case worth mentioning is the Botanic Garden of the University of Modena and Reggio Emilia, specialized since 1996 in the conservation of wild Italian orchid species, which cannot be propagated through conventional methods.<sup>221</sup>

It does not surprise that research actions are facilitated in the case of botanic gardens annexed to a University, however, all gardens can give their contribution in different ways. The establishment of strong partnerships is definitely the most relevant act that institutions can carry out nowadays, just as it was fundamental in the past. The only difference is that currently the cooperative networks can be made official and can, therefore, interact with public institutions as a single more powerful entity. Indeed, the BGCI association, which is an official network of botanic gardens (including a considerable number of European gardens), made possible the compilation of the previously mentioned *Action Plan for Botanic Gardens in the EU*, which offers a structured guide with the needs and possible accomplishments of modern botanical institutions.<sup>222</sup>

It is always in the spirit of cooperation that the *index seminum* initiative began. By creating official lists of all the species and varieties grown by each botanical garden, institutions can request and propose plant exchanges in a much easier way than in the past. Although today, the seed banks are becoming more and more relevant in this process.

Meanwhile, at the national level, in Italy there exists a Network, which is part of the Italian Botanical Society, called the *Working Group for Botanic Gardens and Historical Gardens*. It was

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<sup>220</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.40-43

<sup>221</sup> BGCI. 2000. *Action Plan for Botanic Gardens in the European Union*. p.19

<sup>222</sup> BGCI. 2000. *Action Plan for Botanic Gardens in the European Union*. p.10



founded in 1969 with the primary aim of implementing and supporting high standards in education within botanic institutions.<sup>223</sup>

Moreover, the importance of creating bonds is not only useful for research or horticultural purposes, it can be a real game changer even in the case of economic or management support.

For example, the non-profit association of the *Network of Botanic Gardens of Lombardy*, (created in 2002), is now a key component for the functioning of botanic gardens in the region of Lombardy.<sup>224</sup> It facilitates the approval of projects or activities for many small entities which do not have a structured logistic system as major institutions. And one of these smaller institutions is the Botanic Garden of Bergamo, of which the case study of this thesis is concerned.

## 2.2 Case Study at the Botanic Garden of Bergamo 'Lorenzo Rota'

Gardens are not the perfect comprehensive representation of the values of a nation, a region, or a city; each garden is born according to someone's will to create a locus. The funding members and the garden directors after them are an integral part of the garden essence itself and each of them infuses his or her own view. Values are not universal, but they can vary over time depending on the main individual in charge of *taking care* of it. Just as people are different, so are gardens: a mass of evolving experiences.

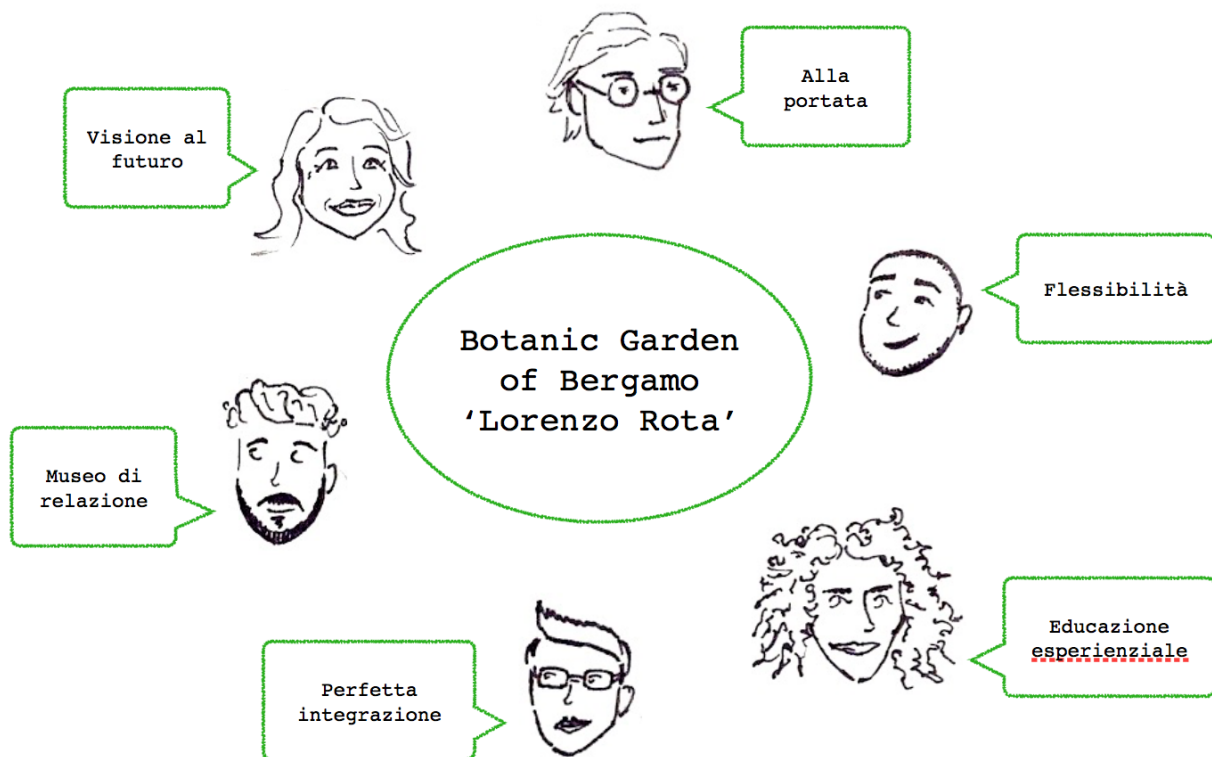
During my internship experience at the Botanic Garden of Bergamo, I had the possibility to begin to feel part of something, part of a story in the making. This chapter is dedicated to this experience and to all the elements that I believe make the Botanic Garden in Bergamo unique, hoping that I will be able to transmit them to the reader of this thesis.

In contrast with the previous chapters, the thesis will proceed now according to the macro themes that emerged from the interviews with the staff of the botanic garden, instead of proceeding in a chronological order.

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<sup>223</sup> C. PERINI, N. TORNADORE. 2004. *The Italian Botanical Society and Botanic Gardens in service to raise awareness of plant diversity conservation*.

<sup>224</sup> Rete Orti Botanici della Lombardia. Chi siamo. (Last visit 16/03/2023). <https://www.reteortibotanicilombardia.it/chi-siamo/>



The interviews were carried out in a non-structured way during my internship (May-October 2022). I tried to let every individual express himself or herself in the way they preferred and with the time they preferred. The attempt was to get to know their story and how it intertwined with the institution. I interviewed a total number of 12 people (4 male and 8 female), of age ranging from 16 to 70 years old.

The **six themes** I identified throughout the interviews are: Museo di relazione (Relation museum), Educazione esperienziale (Experiential education), Alla portata delle persone (At hand), Flessibilità (Flexibility), Integrazione (Integration), Visione volta al futuro (Future oriented vision).

### *Museo di Relazione - Museum of Relation*

This expression comes from a formative meeting of the staff of the Botanic Garden with the now vice-rector of the University of Pavia, Professor Giampaolo Azzoni, (expert in philosophy of law). The encounter took place in 2013, but the garden's curator Francesco Zonca still recalls it with great enthusiasm and considers it an illuminating moment. Indeed, it shed light on the social role that museums can play, especially a botanic garden, which is an open museum in many ways.

The Garden of Bergamo was already practicing several actions of social relevance and relying on many types of relationships, yet they did not become fully aware of it until then. It was an

occasion of growth for the staff and for the institution itself and it allows me to open several sub-themes.

First, we shall analyze the most obvious element included in the former expression: the botanic garden is a **museum**. This equivalence of botanic garden and museal institution should not be taken for granted. In fact, it has not always been the case.

For what concerns Bergamo's garden, it was recognized officially by the regional authorities in 2003. In the same year, Francesco Zonca arrived at the institution through the civil service while he was still a student and the Network of Botanic Gardens of Lombardy was newly born.

Being recognized is a key factor for self-awareness, awakening and independence. In origin, the garden was born in 1972 over only 1'350 square meters of public land, mainly for aesthetic/entertainment purposes. It was projected by a small group of local flora and alpine habitat's lovers (in particular, the engineer Luciano Malanchini and the agronomist Guido Isnenghi).<sup>225</sup> Then, there had been some unfortunate years of abandonment until 1989, when the local administration decided to revive it by calling a conservationist to manage it (the actual director, Gabriele Rinaldi). Nonetheless, it was initially under the wing of the Natural Science Museum of Bergamo and only in 2003 it finally gained its independence as a self-standing institution, with its own budget and management.

There has always been a stigma towards botanic gardens by standard museums, because having a living collection can be messy, unorganized, not fixed, and some academics put it on the same level as simple gardening. Yet there is so much more.

It is the real beauty of it, the fact that plants shall not be considered as fixed objects that stand still in time. And it is also a risk for many directors to fall into the trap of attempting to keep things always the same when nature's essence is to constantly mutate.

Even though the scientific purpose of a botanic garden is to represent the specific taxonomic species known to mankind, plants will never fit into a fixed definition or identification forever. For instance, the biological species theories are often challenged by plants for their ability of interbreeding, their high morphological variability and the consistent differences at genetic level from the animal kingdom.<sup>226</sup> At times they simply surprise us when we least expect it, like the

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<sup>225</sup> Comune di Bergamo. 2020. *Orto Botanico di Bergamo*, Lorenzo Rota. Report 2020. p.7

<sup>226</sup> Quentin D. WHEELER, Rudolf MEIER. 2000. *Species Concepts and Phylogenetic Theory: A debate*. Columbia University Press. p.166

water lily (*Victoria boliviana*) that was mistakenly believed to be a different species (*V. amazonica*) for almost two centuries in the Kew Gardens greenhouse until last year.<sup>227</sup>

The clash of rational thinking for conservation and classification with the living flexible world of plants is a real struggle in every botanic institution, as well as an opportunity for great inspiration.

When in 2003 the Garden gained its museum title, it was the greatest opportunity of change they ever had. Resources were almost non-existent, the staff was incredibly limited (1-2 people), but the potential for action was enormous and so their story started taking shape. Since then, Gabriele and Francesco had been inseparable, both among themselves and the institution. Their work and relationship has definitely left an imprint on the garden's personality.

In fact, moving back to our theme 'relation museum', there is another word which holds much meaning: **relation**. The capability to build connections. A very modern approach to conservation is the understanding that museums can and should have an active and interactive role.

Indeed, a botanic garden thrives on the relationship between plants and people, but also on the relationships among people themselves, and among larger actors. Thus, being more aware of these relations, supporting and incrementing them can only bring a positive outcome.

Some people commit the error of thinking that biodiversity conservation means only dealing with wildlife and that there is no need to deal with the people. This is not the case. Actually, you have to deal a lot with the people, for the same reason that we are part of nature itself, it is necessary to stop thinking that nature and society are separate worlds.

Whether or not they were fully conscious of these considerations, at the Garden of Bergamo relations have always had a fundamental role for its functioning. At first, probably, for matters of support and having more people and associations to rely on, but it slowly created interdependencies. Promoting local businesses by holding events at the botanic garden is a way to bring more audience to the garden and to make them more informed of the local partners of the city.

Today, connections are the Botanic Garden's major strength as they account for hundreds of collaborations with other institutions, cultural associations, local businesses, volunteers, artists, botanists, educators, schools and universities, and so on.

In the offices there is always a nice feeling with people coming and going, students, gardeners, interns, staff, educators, other collaborators and, why not, even family and friends at times. The

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<sup>227</sup> Royal Botanic Gardens, Kew. Grace Brewer. (4 July 2022). *Uncovering the giant waterlily: A botanical wonder of the world*. <https://www.kew.org/read-and-watch/new-giant-waterlily-victoria-boliviana-discovered-at-kew>

attempt at socializing and creating an informal environment has always been a prerogative for the director. And this is a theme that, as we have seen in the first chapter, goes way back in time, when every respectable botanist would rely on his connections to implement his research or amplify his collection and ideas. As for the botanist from the 16th century, Carolus Clusius, who mentioned the importance of friendship in terms of mutual assistance and kinship in his epistolary correspondence.<sup>228</sup>

In sum, social isolation would be a suicidal move for a botanic garden, yet in Bergamo not only they are well aware of that, but they also implement and enrich such connections by promoting innumerable events and activities each year.

The wide range of activities carried out at the botanic garden is indeed surprising when considering that the fixed staff members (with an indeterminate contract) are only 4 plus the gardener, and the fourth was just a recent gain in early 2023. The comitive is composed of the director (Gabriele Rinaldi), the curator (Francesco Zonca), an administrator (Mario Arrigoni), and a person in charge of the educational sector (Mara Sugni). Other than them, there is a variable number of occasional collaborators, for short or longer periods of time: interns, civil service workers, volunteers, educators, artists and experts of different sectors.

The volunteer network and the non-profit Association of the Friends of the Botanic Garden of Bergamo (founded in 2012) are very relevant for showing the growth of the institution, which started with a few individuals and accounts for more than 60 volunteers (2022) and 28 (2017) members of the Association today. The possibility to be hands-on in a semi-natural environment and to support a public service is not only an opportunity for the promotion of wellbeing open to all social classes and people of any age and profession, but it is also an opportunity for the botanical garden to grow roots within the social fabric of the city.

In a regional dimension, the Garden is part of the Network of Botanic Gardens of Lombardy, as already mentioned. While at the national level it cooperates with the SBI (Italian Botanical Society) as it is part of the Working Group of Botanic and Historical Gardens of Italy and Gabriele, in particular, is part of the board of directors of the Working Group.

The networks do not end here. There has been an exponential ramification thanks to the collaboration with international networks and projects, which have contributed to raising the reputation of this young institution.

First of all it is a member of the BGCI, and, since 1994 it also entered the EuroGard consortium of European botanic gardens.<sup>229</sup>

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<sup>228</sup> F. EGMOND. 2007. *Clusius and friends: Cultures of exchange in the circles of European naturalists*. p.36-38

<sup>229</sup> Comune di Bergamo. 2020. *Orto Botanico di Bergamo, Lorenzo Rota. Report 2020*. p.30

The most relevant European projects to which Bergamo’s Garden took part are: Big Picnic (2016-19), Increase (2020-26), Food Trails (2020-24), and Bee Path-net Reloaded (2021-22). Such projects have given weight and support to the management decisions of the director, showing how resourcefulness can reward even small institutions with consistent funding in order to carry on activities connected to current modern issues, like food security and urban as well as agricultural biodiversity.

The “Big Picnic, good for you, good for the planet” project, organized by the BGCI, was the jumping platform for the garden on a wider European scene and it demonstrated to the local administration that they deserved more economic support. It also fit perfectly in the values promoted by the director, which theorized and made possible the section of Astino, the so-called Biodiversity Valley, inaugurated in 2015 when Milan hosted the World Expo “Feeding the planet, Energy for Life”. This section is, in fact, dedicated to food crops (today over a thousand different varieties) and has the intent to demonstrate the incredible diversity that agricultural processes can perform and protect, when caring for food security through genetic variability and local traditions.

Since I arrived at the institution only in 2022, during my internship period I was personally involved in the most recent European project Bee Path-net Reloaded, which is the second edition of a successful international program born in Ljubljana in 2020, to implement urban beekeeping and biodiversity in cities. I witnessed the wide web of relations with ULG partners that a single project can create within the city and I will use it as an example to give an idea of this urban wide web, which in Bergamo was led by the botanic garden institute. (Figure 1)

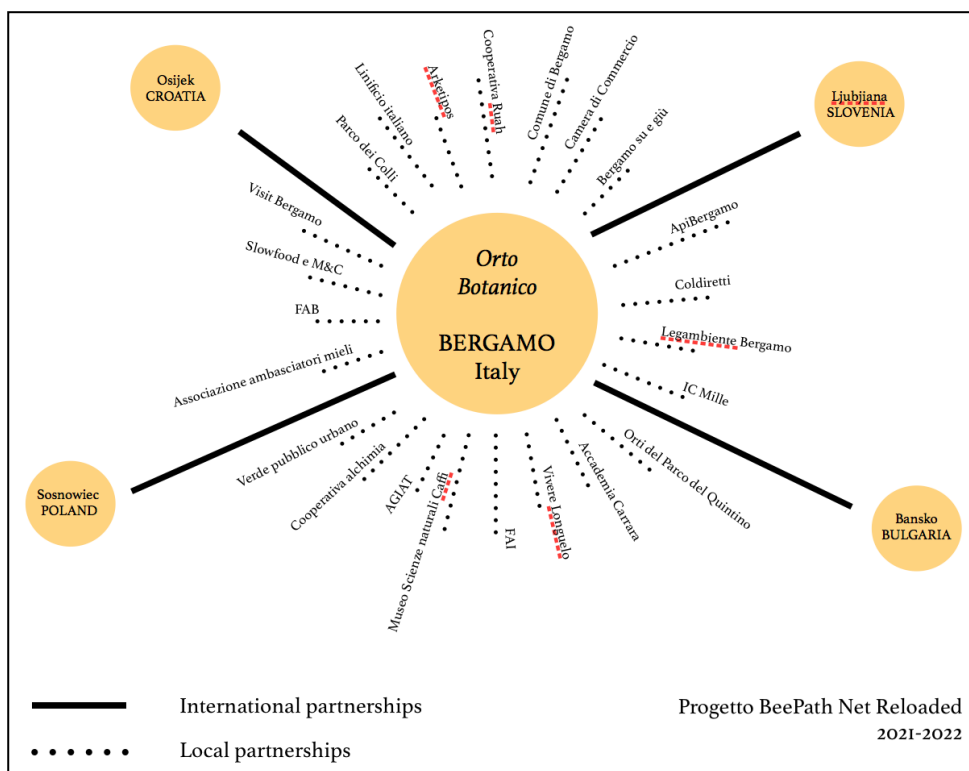


Figure 1. Conceptual map of the partnership web of relations created for the European BeePath Net Reloaded Project

*Educazione esperienziale - Experiential education*

*I sincerely believe that for the child, and for the parent seeking to guide him, it is not half so important to **know** as to **feel***

*- Rachel Carson*

Through the years and the contribution of several figures, the **educational vocation** of the Botanic Garden of Bergamo has flourished, becoming its second strongest point.

Such a feature was confirmed and consolidated in the last years since, in 2023, the Botanic Garden of Bergamo became the first in Italy to have a full time head of educational activity, when Mara Sugni gained the position through public selection.

Mara has been a collaborator for many years, until very recently she has been working as an independent consultant. For reasons of distance she started collaborating with the educational activities in Villa Carlotta, a historical residence with a garden in Tremezzo, on the Como lake, close to where she lives. But eventually, she renewed her ties with Bergamo, where she feels that the social environment is more stimulating for her. And, in fact, it did give positive results with her new working position.

She is a very interdisciplinary figure and takes up the role of environmental educator, which is not yet a professional figure recognized in Italy. Her academic experience was originally scientific, with a degree in biology in Milan, as well as practical, when she obtained the certificate as gardener at the Agrarian School in Monza. Later on her interests in education sprouted and she felt it was more suited for her career. Her experience is also enriched by some formative courses from the Anglo-Saxon world, learning from the BGCI communication experiences. The staff of the Botanic Garden also had a trip to the Kew Gardens of London to apprehend the theme of active learning and the theories on global learning outcomes.

They always attempted at finding the best ways to get deep into people, more than into topics. Understanding more of how the learning processes work, can make educational activities more effective and turn the museum into a speaking entity.

Direct frontal teaching is a very common traditional method used in Italian schools. However, they have experimented how a more interactive approach, less frontal or downward (teacher-student), can be the best in engaging the learners, putting them on the same level as the educator.

Mara follows the idea that knowledge is built collectively, through social cooperation, thus group works are a common tool in the laboratories and activities planned at the garden and it also helps with managing large classes due to the limited spaces of the site.

Moreover, the other element that seals knowledge within our memory is emotions. *The idea of having fun rather than teaching*<sup>230</sup> can be found in Rachel Carson's book *A Sense of Wonder*. The famous scientist, to which the environmentalist movement can be led back to, dedicated her final years to this special essay concerned with winning the challenge of increasing awareness in people by going at its core: the years of childhood. She was convinced that the secret of self-conscious world loving adults is the instillation of a sense of wonder in children so powerful that will last for their whole life. And that can be only done through feeling and sensing the natural world, not with knowledge.<sup>231</sup>

Many of the activities developed by Mara and other educators in Bergamo give prime importance to this concept of creating stories and enjoying moments, rather than instructing the kids directly on what are the functions of plants and animals in the ecological cycles of life.

In particular, using all of our senses will amplify the feelings connected to a specific moment and will open our mind to the things that we normally do not notice in our daily lives. Some examples of activities of perception are: blindfolded explorations in couples, smell tests, listening to the sounds of nature, multidimensional landscape art with natural elements, and so on.

For instance, the blindfolded action is particularly fascinating for me because it presupposes a moment of trust not only in your partner for the activity, but also trust towards natural elements which we cannot see or control. And I personally believe that it could turn into a positive attitude to life in general, learning to trust people and nature together. The activity in practical terms is very simple. The group is divided in couples, each composed by a guide and a blindfolded individual (who will change in turns); the objective of the couple is to lead the blindfolded person from a common starting point towards a plant specimen and let him feel with all his senses (except the sight) this entity, so that later on when the person will get back to the starting point and remove the blinders he will be able to find again the same plant that he experienced while blindfolded.

Through this example you can see how a botanical garden is a perfect safe place for experimentation, for learning in the making, through mistakes, games and cheerfulness in a semi-controlled natural environment. Especially for the newer generations of children who grow up in cities and have very limited access to natural areas in the age of development.

In fact, according to a research carried out in the Bergamo province by the Botanic Garden in 2009, and then confronted with newer data in 2018, it has been found that the gap is increasing

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<sup>230</sup> Rachel CARSON. 1956. *The Sense of Wonder. A celebration of nature for parents and children.* (ed. 1998). HarperCollins Publisher. p.19

<sup>231</sup> CARSON. 1956. *The Sense of Wonder.* p.49-50



between children and nature every year. Through a demoscopic survey carried out in schools from primary to university level (4'000 data analyzed), they discovered how the younger generations are becoming more and more oblivious of the natural processes of plants and that they spend less and less time outdoors. There is a growing ignorance even on what plants are: for example, the percentage of students that did know that cotton is a plant went from 55% in 2009 to 28% in 2018.<sup>232</sup>

In response to the results of these findings they realized how important for botanic gardens is to intervene actively in cooperating with schools and families for allowing children to have as much as possible outdoors hands-on experiences.

And they deserve a moment of appreciation for the growing interest of schools in the formative package of activities proposed by the garden of Bergamo. The activities that were originally only occasional and based on volunteering guides were formalized in 1994, when they touched 629 schools. Within fifteen years it grew exponentially to 7'398 schools in 2018. In the case of educational activities, as well as for the visitors' affluence, there has been a reduction during the Covid-19 pandemic, but in 2022 the numbers started to grow again with 1'532 schools involved (353 pre-schools, 490 elementary schools, 302 middle schools and 387 high schools) and it seems like they will not stop there in the future.

However, the involvement with children does not end with school, the same approach goes for summer camps, to which I had the opportunity to cooperate in June 2022. For a week I supported the work of an educator, Francesca Pugni, who also has a similar imprint based on hands-on experience as other educators who work at the Botanic Garden of Bergamo. She used to bring a series of different tools, games and books that focus on supporting children creativity in altering their perception of reality, such as monocles with a multifaceted glass that recalls the eyes of some insects, portable zooming lenses or colored panels that only let some colors come through.

I was also welcomed to contribute with my ideas for the activities and during said week I had the opportunity to put in practice one of them. I wanted to bring up a topic relevant to me, that I came across during my academic studies, the 'plant blindness' phenomenon briefly mentioned in Chapter I. This phenomenon indicates a biased tendency of humans to notice or value more animals than plants, which scholars believe to be attributable to biological patterns of cognition and perception, as well as to cultural and psychological factors.<sup>233</sup> Through a little experiment I

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<sup>232</sup> Conference *50 Anni Verdi*. Storia dell'Orto Botanico di Bergamo 'Lorenzo Rota'. 11th October 2022.

<https://www.youtube.com/watch?v=HYtpWG8-HtI>

<sup>233</sup> M. BALDING, K. WILLIAMS. 2016. *Plant blindness and the implications for plant conservation*. *Conservation biology*, 30(6): 1192-1199. p.1193-1194

planned on letting the children reach similar conclusions by deduction and discussion and it positively succeeded. I prepared a large poster with no text, only mixed photos of different animals and plants clearly visible to cover the entire poster. The educator and I asked the kids (a dozen of age between 6 and 11 years old) if they wanted to participate in an experiment, but without specifying anything of the content of it. The first part consists in simple observation; we created silence and asked the kids to look at the images for more or less 1 minute. After that, the poster was closed and hidden. From then on, it was all about interactive discussion. The first question we asked them was to say out loud the first image they could recall, with their own words, no need of a specific scientific name of a species. The second question was, instead, to cooperate to try and remember all of the images on the poster. Guess what happened? The first images that were mentioned were mostly of animals, and after much effort to reconstruct the whole ensemble the children managed to mention all the animals, but not all the plants. The result is clearly in line with the plant blindness tendency, and after pointing it out we asked to explain to us why do they think it happens. Once again, the responses were not far from the academic explanation of researchers, but only in simpler terms: they said that plants both in colors, position and movement can be less appealing, visible or cute than animals, or that animals can be dangerous in some cases and it is important to look out for them, but in general that there is more possibility of interaction than with plants.

Hopefully the experiment was useful to inspire some to be more curious about our fellow green friends and to discover how they can be worthy of attention too, for those that know where to look.

### *Alla portata - At hand*

The third theme is directly connected to the first one we explored; for the exact reason that biodiversity conservation needs to involve people, an institution such as a botanic garden needs to be in everyone's reach, in order to involve as many people as possible.

Being at hand is definitely one of the guiding values for the director, Gabriele, who has always fought for keeping the botanic garden as a public good, **a place for the people**. In other words, this means to create a pleasant and informal environment, where everyone is welcome and can reconnect with natural elements, which is also free of an entrance fee.

Even though it has a scientific and educational role, it can be used as a stage for cultural and social events that might not be strictly connected to botany, but will lure even non-plant enthusiasts to this place. It is a simple way of thinking out of the box.

For instance, during the time of my internship, a music concert and a traditional Indian dance exhibition took place in Astino, which also offers an opportunity for local individuals or groups to reach a larger audience. Not that the activities connected to the flora are few, for kids, as we saw while focusing on education, but for adults as well.

Moreover, the informality reaches the offices too. I have always perceived an easy going environment, very welcoming, open to idea sharing and communication.

Moving back to the decision to persevere in maintaining free entrance to the garden, it is necessary to say that such a feature is very rare among botanical institutions and museums. Yet, cost can be perceived as a barrier, while the gratuity puts it at the same level as a public park: perfect for local citizens' weekly walk and most likely a stop for occasional tourists.

Indeed, the data on visitors' records have shown a growing trend from 14 '837 visitors in 2003, except during the pandemic years in which the affluence halved compared to the previous ones. In fact, in 2019 there were more than 70'000 visitors counting the 3 sections of the garden: Città Alta (36' 759), Astino (18'788) and Sala Viscontea (16'781), of which 5'777 students for school activities. On the contrary, the year after, due to the Covid-19 pandemic, the total number lowered to 30'665 visitors.

Luckily, the recovery is quick: in 2022 it started growing again steadily with the outstanding number of 73'989 visitors, of which 2'665 students.

The dislocation of the botanic garden was not intentional, it simply happened with time, whenever the chance to enlarge the spaces open to the public was available. In some ways it can be dispersive, yet it has increased the opportunities of encounter with different users and they can serve various functions.

#### 1. Section of Città Alta - A window on the landscape:

It is located at the top of the old city centre and it is the original garden position, with a view on the Bergamo Valley. With its few 3'000 square meters it holds the main living collection, generally divided by eco-geographical or thematic areas, but with no clear-cut divisions. This means local flora, a few alpine species, mediterranean flora, exotic taxa from all continents, some aquatic plants and so on.

#### 2. Section of Sala Viscontea:

Just a few minutes on foot by the garden and in front of the offices, there is this multipurpose room inside a historical building from the 1300, which has been restored and opened to the public in 2005. In here are hosted temporary expositions, galleries, and conferences.

### 3. Section of Astino - Biodiversity Valley:

The latest addition was inaugurated in 2015, close to the Astino monastery, thanks to the financial aid obtained with the Big Picnic project. It consists of 3 hectares dedicated to agro-biodiversity, more than a thousand varieties of plants grown for human purposes. This area is meant to be a reflection on the relationship between humans and plants, and the huge diversity in agro-industry that is going lost or unnoticed in the last decades.

These different spaces have much to offer in terms of space and topics, allowing the botanic garden to host events of all sorts and all year round, even when the weather conditions are not favorable to be outdoor or during winter time, when the botanic garden is officially closed.

Still, spaces are limited in case of consistent numbers and, for this reason, there is normally a cap limitation for school activities or external courses.

Yet, for being an old city centre it is a privilege to have such spaces. For many botanic gardens having a central urban position is now a dream.

In fact, during the urbanization processes, several old cities have become limited and cramped. Thus, local administrations have opted for moving all those elements not considered essential further out in peripheral areas for reasons of space.<sup>234</sup>

Luckily, this was not the case for Bergamo, in which the botanic garden still holds a very central position in the old city. In general, even though the city is one of the busiest cities in Lombardy it maintains one of the best balance of soil use in relation to the inhabitants, not only in the region, but in the entire country scoring 9,5 soil use efficiency on a 1-10 scale.<sup>235</sup> This can be attributed to the decision to protect and re-naturalize the protected areas around the city.<sup>236</sup>

#### *Integrazione - Integration*

The botanic garden of Bergamo is an example of **successful integration** in many ways: it can be seen as a mixture of human and non-human species, different disciplines and different cultural values.

As introduced in the previous theme, it represents the perfect integration of a green semi-natural area within an urban context. A factor highly appreciated by some of the volunteers that I

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<sup>234</sup> CLAUSER, PAVONE. 2016. *Orti Botanici, Eccellenze Italiane*. p.28

<sup>235</sup> Legambiente. 2022. *Ecosistema Urbano, Rapporto sulle Performance Ambientali delle Città nel 2022*. p.202

<sup>236</sup> Legambiente. 2022. *Ecosistema Urbano, Rapporto sulle Performance Ambientali delle Città nel 2022*. p.9-12

talked with, who observed the change of time over the urbanization process of Bergamo and are thankful for the presence of the botanic garden.

Despite the limited spaces, the garden in Città Alta gives the feeling of being much wider than it actually is. This is due to the elongated non-linear path that climbs up on the rocky hill and culminates in a splendid view over the Valle Bergamasca, a jewel to any visitor's first impact.

Being in an urban area should not be a limit for the creation of semi-natural environments in which local biodiversity can find a home. In fact, several species of insects, birds and other small animals can be encountered during a visit at the botanic garden. Much more than in an average urban green area, not only for the rich number of floral species cultivated, but for the healthy horticultural practices used to cultivate them. (Among the more sustainable practices we can find mulching, composting, the use of biological non-chemical pesticides, the manual removal of weeds, the practice of crop rotation in Astino, the integration with crops of specific plant species repellent of detrimental insects and others to lure beneficial pollinators, the use of ancient varieties of fruit trees which are more adapted to the territorial conditions and more resistant to pests, and so on...).

This is relevant especially as an inspiration for citizens. The role of green areas for the reduction of air and noise pollutants and the enhancement of urban biodiversity is fundamental, in particular for the safeguard of pollinators, as underlined by a British research from 2019.<sup>237</sup>

This topic has been developed in the previous years (2021-2022) through the adhesion of Bergamo to the Bee Path Net Reloaded European Project. The Botanic Garden took the lead in creating and managing the community of Urban Local Group (ULG) of actors in Bergamo as shown in the previous conceptual map.

The focus was on bees and honey keepers, yet the activities promoted shed light on many other types of pollinators, which are mainly solitary. The garden staff also got the idea to sponsor a BeeHotel contest for woodwork companies all over the province in 2022. Unfortunately the participation was not high, yet the prototypes presented are now in public spaces and schools and actively offer a safe spot for solitary bees in an urban context.

Moreover, integration can also be seen on a social level at the botanic garden of Bergamo, where there is no requirement to become part of this reality other than motivation.

The most striking case is that of the gardener, Gnaman Kambou, who migrated from Cote d'Ivoire to Italy in 2013. He comes from a poor family that used to work the land, but growing up the situation did not improve. Gnaman had some unfortunate encounters with the authorities,

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<sup>237</sup> K. C. BALDOCK, M. A. GODDARD, et al. 2019. *A systems approach reveals urban pollinator hotspots and conservation opportunities*. *Nature ecology & evolution*, 3(3): 363-373.

until a colonel liberated him from jail and transferred him first to Ghana and later to Europe until he was left with nothing but his documents in the Bergamo station. Today he has managed to bring his family to Italy, he learned Italian, even if he is still not able to read, and works for the botanic garden, once again with the land.<sup>238</sup> He is now a solid member of the crew since he obtained the position of full time gardener in the section of Città Alta.

During my stay, he was the only person officially in charge of garden maintenance. A huge burden to carry in one of the warmest and driest summers ever recorded. Luckily, there was help. Help can come from anyone: volunteers, students, young and old, even people with physical or mental issues.

For example, thanks to the BG+ program many young pupils had the chance to get to know this reality from inside during the summer period (12 teens in 2022). BG+ is a volunteering program organized by the local administration in collaboration with the Volunteer Service Center, the association Solco Città Aperta and the social enterprise HG80; it promotes the inclusion and civic commitment of young kids and teens in the public network of the city.<sup>239</sup>

I had a chat with a young teen who, for personal difficulties, does not live with her family, but in a community. In this community they have an orchard and she told me how gardening has given her much joy and more appreciation for plants. Gradually, she started noticing more the need to get in contact with green areas and how she felt that the cities lack consideration and care for plants. So, when she had the opportunity to volunteer through the BG+ program, during her summer holidays, she chose to come to the botanic garden. Hopefully after her studies in tourism economy, she will be able to turn these feelings into real actions for the promotion of a more sustainable tourism.

In fact, horticulture, imbued of other disciplines' influences (such as education, psychology and medicine), is today widely recognized as a valid method for treating both mental health issues and physical disabilities.<sup>240</sup>

Finally, even me personally, or other technical figures such as the administrator, who do not have a scientific academic background, are welcomed with open arms and have the occasion to

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<sup>238</sup> Lara BORTOLAI, Martino ROVETTA. 2021. *L'Orto Botanico di Bergamo: un incrocio di storie*. Speciale Orti. Babel

<sup>239</sup> Comune di Bergamo. Bergamo per i Giovani. BG+. (Last visit 28/03/2023). <https://giovani.bg.it/attivita-in-corso/bg/>

<sup>240</sup> K. HARRIS, J. TRAUTH. 2020. *Horticulture therapy benefits: A report*. International Journal of Current Science and Multidisciplinary Research, 3(4): 61-65.

voice suggestions and ideas. The chance of working in a friendly environment makes it possible for everyone to contribute in his own way and enrich the institution in so many directions.

For this same reason, we witness such a wide interdisciplinarity at the Botanic Garden of Bergamo. The integration of multiple activities under the same roof is a direct consequence of the diverse people that passed by Bergamo during the years. The activities can be scientific, such as herbarium collection management and seed exchanges between the garden and seed banks; they can also be recreational, such as volunteers' meetings or concerts and art courses; and of course they can be formative, as for conferences on local biodiversity, on the effects of climate change in the pre-alpine area of Lombardy, or courses on gardening and horticultural techniques.

In some cases, people leave an actual trace of their passage when a temporary project or exhibition becomes permanent. For instance, this was the case for the Iris collection, which was brought by Luigi Mostosi for a monographic exhibition. He was a chemist but had a personal interest for *Iridaceae* and even took part in a course in Florence about these plants. Later on he became an hybridizer of iris and specialized his focus on bearded iris. During his life he managed to obtain more than a 100 cultivars and eventually donated these bulbous plants to the city of Bergamo, when the director of the botanic garden decided to dedicate an exhibition to such a contribution in 2002. After some years, around 2007 it was finally created a permanent flowerbed to host these beautiful cultivars, which remained until today.<sup>241</sup>

It is contributions such as this that make gardens like stories in the making, continuously mutating in its physical appearance depending on the social interactions and the interactions between humans and plants.

### *Flessibilità - Flexibility*

The great variety of disciplines and activities performed at the Botanic Garden of Bergamo do imply a certain amount of flexibility to make them possible, especially for the staff, since there is a lot on their plate.

When I arrived, I had to quickly learn that being able to **adapt and be flexible** is probably the most important quality to have in order to align with the working mechanisms of this entity and the hectic flow of the staff.

I believe it to be an ordered chaos, which means there are two sides of the coin. It can be said that there are too many activities going on, which at times can result in rushed planning and

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<sup>241</sup> Conference *L'Orto Botanico di Bergamo raccontato attraverso la storia delle sue collezioni*. 10th November 2022. <https://www.youtube.com/watch?v=9v9JjtqsYbM>

execution. On the other hand, the ability of the team to be resourceful and not giving up on any opportunity is to be admired.

Indeed, during one year (in this case 2022), more than a hundred activities have been carried out, both online (11) and in presence (95). Among the many themes, the activities include ludic laboratories for children and families connected to urban gardening, art, history and music in the garden, pollinators, local flora and useful plants. There are also laboratories, conferences and courses for adults that wish to learn more about horticulture, local flora, beekeeping, products of the land and scientific research on the biodiversity of the area. There have been 3 concerts and a dance exhibition, 12 guided tours in different sections of the botanic garden and even 5 sale events with the extra products of the Astino section to get to know ancient fruits and vegetable seasonal varieties. Last but not least, the Sala Visontea hosted an exhibit on the project “De-pavimentiamoci”, which promotes actions of de-paving urban areas to give back space to plants and nature and showed examples of the sort from all over the world.

The limited economic and technical resources have been compensated by personal experience, friends and volunteers’ support, local businesses, and networks. For instance, the association Friends of the Botanic Garden in 2020 has contributed economically to the realization of an urban horticulture course, and it guaranteed enough personnel for welcoming activities of a botanical art exhibition in cooperation with the University of Bergamo, as well as to the planning of several laboratories for children, online and in presence.<sup>242</sup>

The enrichment of the photographic database of the living collection is currently ongoing thanks to volunteers. Same goes for the rearrangement of plants, vases, bulbs and seeds in the section of Città Alta. And they are open to share whenever there are extra seeds and bulbs. For instance, I received some bags of tulip bulbs that were collected by volunteers at the end of the seasonal cycle of these flowers’ collection in the garden. Moreover, a local cooperative is in charge of the maintenance of the Astino Section, helped by other volunteers.

All of these contributions helped me see how **resilient** the BGB actually is. Being resilient is extremely on point for current times. Everyone is worrying about how to make the environment more resilient, able to adapt to changes. Yet what we cannot forget is that society needs to be resilient too. Cities and organizations cannot rely on structures too fixed, or they will collapse in a fast changing world.

I want to reconnect to the concept of flexibility as proposed by Eriksen in his book *Overheating* in which he applies the term, originally theorized by Bateson, to the modern anthropocentric world. In particular, he proposes how, for example, urban cities have a reduced flexibility due to

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<sup>242</sup> Comune di Bergamo. 2020. *Orto Botanico di Bergamo, Lorenzo Rota. Report 2020*. p.24



the increased complexity of infrastructures and the hyper specialization of roles, which make it very difficult to adapt in case of a sudden crisis or change.<sup>243</sup> I believe that, following this line of thought, the simplicity of the organization of the Botanic Garden of Bergamo is equal to a high flexibility and, thus, it is the strong point of the institution at this point in time, to easily adapt to any requirement of limitation that might present itself.

The varied distribution of the spaces in the city, the limited number of permanent staff which are able to perform different roles or to contact a variegated range of people locally when a new skill is required, or the possibility to adopt several alternatives to obtain funds, are all part of the reason why this entity has a highly flexible organization. And such feature is perfect to adapt to a fast changing world like the modern overheated one we live in.

A very simple example of how this can be seen in practice is the fact that it was one of the few open museums in Italy that most quickly reacted to the Covid-19 pandemic crisis, in order to modify its activities to continue to reach people, even though the limitations were many. In 2020, more than 50 events were organized in presence following the safety regulations, plus an online exhibition open to all regarding the tulip collection, 3 online seminars on topics connected to local flora and fauna and 8 online laboratories for children.<sup>244</sup>

Thousands of people were reached through these activities in a moment most needed and this is admirable. In this sense, the Botanic Garden of Bergamo is one of the most modern gardens in Italy in terms of creative thinking and I believe that, for its high mutability, it has a long future ahead.

*Visione - Future oriented vision*

*Not all botanic gardens have such a determined, strong vision*

- Mara Sugni

The winning element that makes a difference in turning chaos into positive creativity is the **strong vision** of the leading figure of the botanical garden, Gabriele, and of the entire crew. A strong minded leader is necessary for managing complex entities like botanic gardens, as we have seen in the first historical chapter, when botanical visionaries were able to give enormous success and fame to botanic gardens of the past.

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<sup>243</sup> ERIKSEN. 2016. *Overheating*. p.89-91

<sup>244</sup> Comune di Bergamo. 2020. *Orto Botanico di Bergamo, Lorenzo Rota. Report 2020*. p.17-18

Having clear values and objectives is what can mould motivation into the right direction. And the stable growth of the institution is the demonstration that they are actually making a difference in their local context.

Being a young institution might have contributed to the creative building of the garden since there was not a centennial tradition to revolutionize, contrary to several other historical sites that have to deal with modern times in a more oppositional way.

Yet, the modern approach in several aspects was brought by the director, who has grown and lived in Bergamo for all his life and has experienced the urban changes of the city on his skin. The openness to the people, the will to maintain the garden available and free for all, the ambition to create networks at the local, national and international level, and the care about biodiversity of plants as well as other forms of urban biodiversity, are just a few of the key elements that contribute to the complex but strong ideology of this botanic garden.

According to my personal experience and the dialogues that I had with the people involved in the garden, an interactive education and a strong social role are the pillars that guide the management of this institution, devoted to spreading more love for nature and its lifeforms.

But the peculiarity of their approach is simply that themes that are actual today, were already been bravely touched by the activities of the garden more than a decade earlier, when there was not as much consensus or relevance given. One of these is the topic of food security, for instance.

In an innovative way, in Bergamo, alimentary plants were returned to the context of gardens following the creation of the Astino section. As it was expressed in the first chapter, in the very past at the times of the Greeks, Romans and earlier, there was no strict distinction between ornamental plants and useful plants: gardens would encompass them all and still be considered aesthetically pleasing. In modern times this concept has been partially lost due to the strong division in economic sectors between agriculture and gardening. However, some creative botanic gardens, like that of Bergamo, are bringing back the beauty of all plants and are trying to reconnect people with those plants of which we only see the final products in supermarkets and of which, at times, we completely forget their natural cycles.

In that and many other ways, even if the scientific researches for practical actions of conservation are not a priority (contrary to other more historical institutions), this does not limit at all the positive impact of the garden in the city.

The Botanic Garden's name is dedicated to Lorenzo Rota, the first naturalist that described comprehensively the flora of the Bergamo area. He was a doctor who lived more than 150 years ago, truly passionate about botany. The herbarium collection holds most of the data that he left

us.<sup>245</sup> Unfortunately the garden, since it is not officially connected to the local university, has always had a limited potential for scientific research. I noticed how this aspect is partially unexplored for the moment, even if there have been experiences of positive collaboration between the University of Bergamo and the Botanic Garden. This is the case for the conservation efforts of the local endangered fern species *Osmunda regalis*, which was disappearing from the area of Bergamo and was reintroduced a dozen years ago thanks to the help of the botanic garden.

Once again, they can perform any idea that they put their mind to. Thus, hopefully there will be more chances of practical collaborations with the University in the direction of local biodiversity conservation.

### 2.3 Discussion

It results evident that the main values and key activities of the Botanic Garden of Bergamo revolve around its social and educational role. These roles have been strengthening in the last decades and are now consolidated. However, there are some issues regarding the management of the institution, especially the limited economic resources allocated by the municipality.

The investments of the local administration are interested mainly in the growing tourism factor, which is beneficial to the local economy, but it tends to forget that the amount of work performed by the botanic garden would be better if distributed among a wider permanent staff.

Moreover, the avant-garde vision and creative ideas are not met by an equally modern equipment in most cases: the infrastructures are very old, the electric system needs improvement, as well as heating and the air conditioning (absent), half of the computer are outdated or not working efficiently and the internet connection still goes with ethernet cables dangerously lying around. Patches are not sufficient, the technical renovation has to be systemic.

And the limited resources unfortunately affect mostly the non-human component of the botanic garden, especially the living collections and the herbarium, since they require more frequent care and attention.

For instance, during the summer period of 2022, which recorded one of the worst droughts and heatwaves ever in northern Italy, the care required by the plants was higher, but the workforce was too little. I used to visit at least once a week the Section of Città Alta and I noticed the lack of watering for several specimens vulnerable to the unexpected heat, which resulted in burned or weak leaves.

Another case regards the flowerbed dedicated to plants known for dyeing properties. They were a new addition of the year, but unfortunately only half of them survived through the season.

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<sup>245</sup> Gabriele RINALDI. 2009. *Lorenzo Rota 150 Anni Dopo*. Orto Botanico di Bergamo 'Lorenzo Rota'. p.39

This is also connected to the fact that even if there are many volunteers, not all of them are regular in their appearance and the organization is not too strict, thus unpredictable.

However, recently they decided to tackle the issue of volunteers by reorganizing the whole system creating 4 teams dedicated each to a different areas of work (herbarium, hospitality, living collections and education) and requiring more regular contributions.

In sum, the Botanic Garden of Bergamo can be seen as anthropocentric in the sense that, in practice, the focus of actions is on the human/social factors and less on the non-human. And there is a misalignment of rhythm between these elements, the non-human garden processes and the fast paced, hectic human garden processes.

I believe that the staff could build a more personal connection to the living collection, or to plants in their own personal life, in order to deepen the actions of care towards the plant world and better be able to share such passion.

The reason why I reached this conclusion relies on some answers that I retrieved during the interviews. I was curious about memory and plants, so I asked each individual if they could tell me about anecdotes about a specific plant that remained in their personal memory. And I noticed how it was not as immediate as I would have imagined for most of the people to answer. Many do not have a strict relationship with plants, even if they work in constant contact with them, let alone those who do not. Perhaps it could mean that the action of gardening for many is an action of benefit for the person, but not of real interaction at the emotional level with the plants. Indeed, eventually the anecdotes I gathered were always connected to childhood memories, most of the time enhanced by a parent or a family dedicated to gardening or farming.

Urbanization is removing the direct contact with natural or semi-natural environments and we grow up forgetting about it completely, creating a mental distance other than a physical one. I think we need to bond more with our fellow vegetative beings, talk with them, about them and create stories on them. That will be the opening key to getting people to willingly go into further details of local and alien flora, the methods of cultivation, the connections with the soil and the biome. But it cannot be the other way around.

And for many other aspects, the botanic garden of Bergamo has the potential to do this. I could see a positive spark that is what we need today to get in touch with people, the ability to bring them out and learn, to practice hands on and experience with all of our senses. And the ability to create networks and build connections between local actors, and even non local actors. In this sense there is certainly modernity in this institution. However, due to the amount of activities undergoing, bureaucratic processes and lack of structured organization of time, it often results that the staff of the Botanic Garden is too busy in the offices to dedicate enough quality time with experiencing the garden with calm and peace of mind. For instance, if I did not take the

initiative to regularly take my camera and spend a couple of hours of my days among plants, my other duties of research and communication for the Garden would have been completely done behind a desk, in front of a computer. Thus, misaligning me with the real protagonist of what needs to be communicated, the care for plants. I believe that planning some regular meetings for the staff within the garden could help both in *slowing down*, reducing burnouts of the employees as well as *making peace with different temporalities*<sup>246</sup> that are not as accelerated as the technological world we have to work with.

Lastly, one other potential danger for the future of the Botanic Garden of Bergamo is the passing of the baton when the director will retire. Indeed, it has been under the official care of the same individual, Gabriele Rinaldi, for more than 30 years and it is impossible to consider the institution as a separate entity from this person. The strong bonds created with the team and the whole local network gives hope for continuity in the conduction and the values of the botanical institution. Yet, botanic gardens are very susceptible to changes and when he will retire, it might affect the equilibriums. Change that might lead to a different institution as a whole.

I cannot wait to see what will happen next.

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<sup>246</sup> M. PUIG DE LA BELLACASA. 2015. *Making time for soil: Technoscientific futurity and the pace of care*. Social studies of science, 45(5), 691-716. p.19

## Chapter 3. Adaptation to Climate Change

The third chapter is dedicated to the specific issue of climate change and its consequences, with some insights on the specific vulnerability of Italy. It will also be illustrated the relation between climate change and botanic gardens and what are the actions that can be put into practice. Moreover, there will be an analytic section that will attempt at applying the Climate Assessment Tool to the Botanic Garden of Bergamo inspired by the Landscape Succession Strategy of the Royal Botanic Gardens of Melbourne.

### *3.1 Introduction to the Climate Change Phenomenon and Repercussions in Northern Italy*

In this section we will deal with two of the most dreaded and yet most popular words of the last decade, climate change, first by looking at what it is and subsequently at the possible consequences.

A climatic change involves a **long term** change on a **large scale**, which in this case is the Earth's global climate system. It is important to specify these features since they are the main determining factor that distinguish climate from weather. Indeed, all current and past researches concerning climate change have dealt with temporal scales that go from centuries to millennia, to even million of years, and with data gathered from all possible sources around the globe.

In other words, the temperature you are experiencing right now is very specific and localized, like the presence of the sun, clouds, wind or rain and humidity is the current weather. These factors are partially dependent on the climate, but are not the general climate of the area in which you live and neither the climate of the entire region. The climate is more like an average of the weather of an area, and the consensus among climatologists is to consider, at least, a range period of 30 years to determine the climate of a region. As once said, *climate is what we expect, weather is what we get.*<sup>247</sup>

Nonetheless, contrary to simplistic assumptions, the climate is not always the same, both climate and weather are very variable! With regards to any natural phenomenon or process, perfect stillness does not exist. There can be a situation of apparent equilibrium, but it will always be temporary. A climatic change is the simple transitional period from a situation of equilibrium to a new different equilibrium.

According to climate and paleoclimate studies, the Earth has experienced several climatic changes and some abrupt catastrophic changes during its very very long life (4.5 billion years).

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<sup>247</sup> Jeff ANDRESEN, Claire N. LAYMAN, Julie E. DOLL. et al. 2012. *Climate Basics*. Climate Change and Agriculture Fact Sheet Series. Michigan State University, Extension Bulletin E3151.

However, there is not one simple cyclicity, but several natural cycles that influence the global climate and each with a different periodicity. The forcing factors that can drive a climatic change can be both external and internal to the Earth system. For instance, some major influential factors are external because they are connected to the solar energy distribution over the surface of the planet: the changes of tilt in the planet's rotation axis (41'000 year cycle), or in the eccentricity of its orbit around the sun (100'000 and 413'000 years cycle).<sup>248</sup> But there are also internal elements that contribute in influencing all the others: like the tectonic movements, the composition of the biosphere (living beings), or that of the atmosphere (air). And considering that cycles do overlap in real life, it is almost impossible to distinguish their effects separately and that is why foreseeing future changes is a very complex task that can only be performed by accepting a certain level of uncertainty.

Nonetheless, studying the past is useful to understand our present and future, thus climate scientists have developed and confronted dynamic models that attempt at considering all the major factors together and it was possible to match the somewhat regular oscillations in the history of the Earth's climate. There are incredibly long-term oscillations as well as less long-term oscillations. In general, to simplify things, we could think of the Earth's climate as an alternation of glacial (cold periods) and interglacial periods (warmer periods), of different extension and intensity over time.

In this context, it is also relevant to specify that even if the major periods are called glacial and interglacial, the magic of the earth is its capability to always maintain a certain self-balance that prevents the system to go over critical extremes and, for example, end up completely frozen or too hot, as Venus, which is has a temperature too high to allow life.<sup>249</sup>

Said magic is actually the complex ensemble of interrelations of all of the Earth's innumerable variants: the biosphere (living beings), the atmosphere (air), the lithosphere (lands), the oceans and the cryosphere (ice). And every single one of them (plus the external elements depending on astronomical processes) is to be studied in terms of **forcing and responses** (factors that cause changes and the resulting effects).<sup>250</sup> Because not only they can cause changes, but each element can respond differently to said changes, some within a few years (such as the atmosphere), some others within centuries and millennia (such as the oceans and the cryosphere).

Also for this reason, depending on the temporal scale that is chosen to be studied, what we will see can differ very much. Let's take a painting as reference: watching a painting from far away

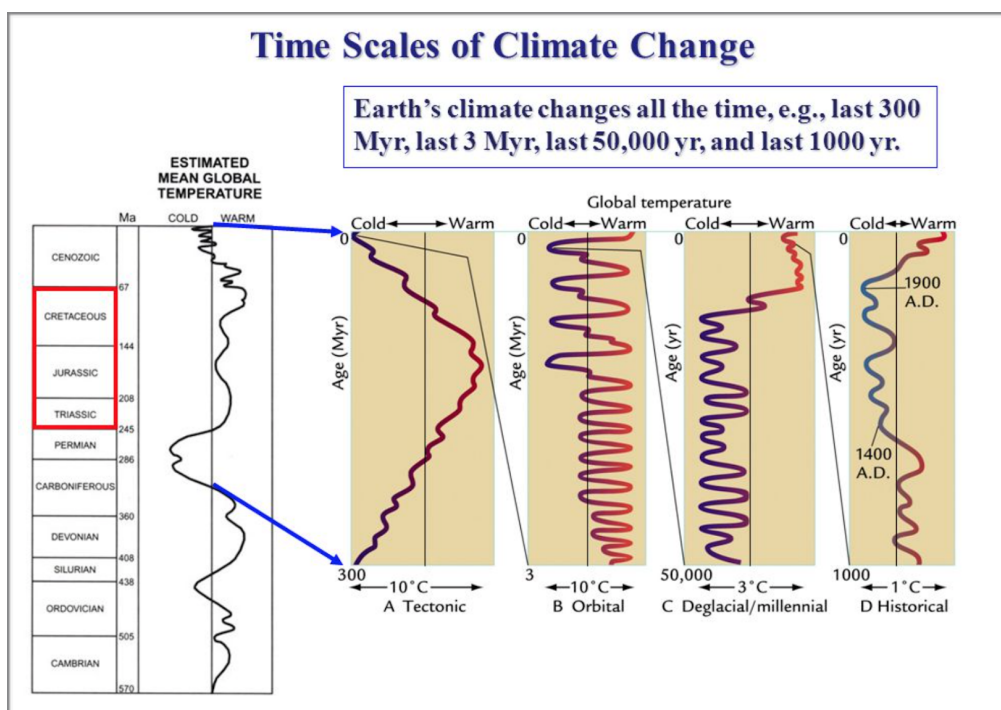
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<sup>248</sup> William F. RUDDIMAN. 2014. *Earth's Climate: Past and Future*. 3rd edition. Macmillan Education. p.159-164

<sup>249</sup> RUDDIMAN. 2014. *Earth's Climate*. p.81

<sup>250</sup> RUDDIMAN. 2014. *Earth's Climate*. p.8

and close up can reveal very different aspects. From far away we see the overall picture, the large shapes and their contours, and the main colors used; on the other hand, the closer we get to the canvas, the smaller is the portion of painting we focus on, but we can see more details in terms of single brush strokes and more nuances of the colors. Looking at the Earth's climate is very similar depending if we want to look at 2 billion years of history or just the last millennia. Especially for deep past epochs of the Earth, of which we have very little understanding and data of, the temperature gradients can be in terms of 10 degrees during hundreds of millions of years and smaller oscillations of 1-2°C can be of little relevance over such longer term processes. On the contrary, within a small period of time, that 1 or 2°C gradient can, indeed, have huge impacts on the life of the Earth.<sup>251</sup> (As depicted in Figure 2)



**Figure 2.**  
*Different time scales of Climate Change*<sup>252</sup>

The complexity of the situation can lead to a misinterpretation of the data we have, by looking at single numbers without a context. For instance, according to our current knowledge, the average temperature of the planet has been much higher than today (assuming pre-industrial levels as baseline temperature) during the Cretaceous period (around 100 Myrs ago) with an average of 8°C higher and even more during the beginning of the Paleozoic era (around 500 Myrs ago) with an average temperature of 14°C higher.<sup>253</sup> Yet, the Earth's face looked very different at that time. It is so distant from us that we would not be able to recognize it as the Earth we know.

<sup>251</sup> RUDDIMAN. 2014. *Earth's Climate*. p.6

<sup>252</sup> RUDDIMAN. 2014. *Earth's Climate*. p.7

<sup>253</sup> Wikipedia. Geologic temperature record. (Last edited, December 2022). [https://en.wikipedia.org/wiki/Geologic\\_temperature\\_record](https://en.wikipedia.org/wiki/Geologic_temperature_record)



In any case, instead of focusing too much on a number, what we should focus on is what drives the temperature changes. And for what we understand, the Earth is now under a process of warming for reasons that are new to the Earth and that can lead to unknown responses of the global system.

Following the natural trends and oscillations, the climate should undergo a new glacial period, which has not occurred. On the contrary, the Earth is warming up. The defining factor that we have to add into our scientific calculations is a new human factor, the factor that led to the Anthropocene, an epoch in which the global system is being impacted by human activities.<sup>254</sup> In fact, according to most studies, carbon dioxide (CO<sub>2</sub>) levels have always been a consequence of global temperature changes, instead, right now we are assisting an opposite process in which the temperatures is driven by the change in carbon dioxide in the atmosphere.<sup>255</sup>

Within large scale phenomena it is of course possible to find exceptions at a local level due to the complexity of the various spheres of the Earth and its infinite variabilities. However, the global average is going in an unexpected direction and at a very fast rhythm. And up to date, there is global consensus that this process is being driven by human activity, as stated in the last Assessment Reports (AR6) of the IPCC.<sup>256</sup>

How human beings were able to acknowledge their impact and how they responded, is also a quite complex and long story, but we can try to summarize the most recent turning points.

The first time it was discussed on an international level among the major world governments was in 1968 at the UN General Assembly, which was held in Stockholm. The Swedish ambassador Aström had a speech on CO<sub>2</sub> emissions and its consequences.<sup>257</sup> In particular, that anthropic activities were causing an excessive emission of greenhouse gases into the atmosphere and that could pose a serious milestone into a positive feedback mechanism (self-reinforcing mechanism that leads to an increase in temperature).

However, once there was not as much knowledge as today over this topic and it resulted evident that there was a strong need for investments in reinforcing this field of research. Thus, in 1988 the IPCC was created by UNEP (United Nations Environment Programme) and WMO

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<sup>254</sup> RUDDIMAN. 2014. *Earth's Climate*. p.293

<sup>255</sup> Angelo RUBINO, Davide ZANCHETTIN. 2010. *Riscaldamento globale: La fine*. p.71

<sup>256</sup> IPCC. 2023. *Climate Change 2023: Synthesis Report*. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland. p.6

<sup>257</sup> Tsuru SHIGETO. 1999. *The Political Economy of the Environment*. p.199

(World Meteorological Organization) with the sole scope of carrying out and implementing extensive research on climate change, its causes and its possible outcomes, so that international policy could be carried out with the most up to date knowledge as possible.<sup>258</sup>

The results of the different IPCC working groups are regularly and systematically organized in Assessment Reports (AR): since the first assessment report released in 1990 (AR1), more or less once every six or seven years a new report has been released; the latest was published in 2023 (AR6, Synthesis Report).<sup>259</sup>

To summarize, the general understanding of the Earth's climate system is dependent on how energy moves in and out of the planet: the sun is the energy source, the atmosphere has the double role of protecting the Earth from receiving too much energy and keeping in just the right quantity to allow life (thanks to the greenhouse gases); subsequently, the unequal energy that enters the system causes several processes to happen, such as the atmospheric and oceanic circulation, which are at the origin of global climatic zones. These influences the disposition of water on Earth, in its liquid, gaseous and solid form, and, consequently the biomes (the different biological habitats of Earth). For reasons of time and focus, I cannot delve too deep in the climate dynamics, this is an incredibly brief and oversimplified explanation. Thus, some elements might seem more relevant than others, but I want to bring an example of how each component can have a domino effect on the others. And, considering that plants are the protagonists in this thesis, I decided to describe the effects that vegetation can have on climate.

First of all, plants, as all other living beings, are strictly connected to the carbon cycle of the Earth: they can be both a sink and a source of carbon. All living beings on Earth are organic carbon sinks, since carbon is a building unit of life. And plants are the most influential biomass on Earth as demonstrated in Figure 3, ( $\approx 450$  Gt C out of the  $\approx 550$  total Gt C).<sup>260</sup>

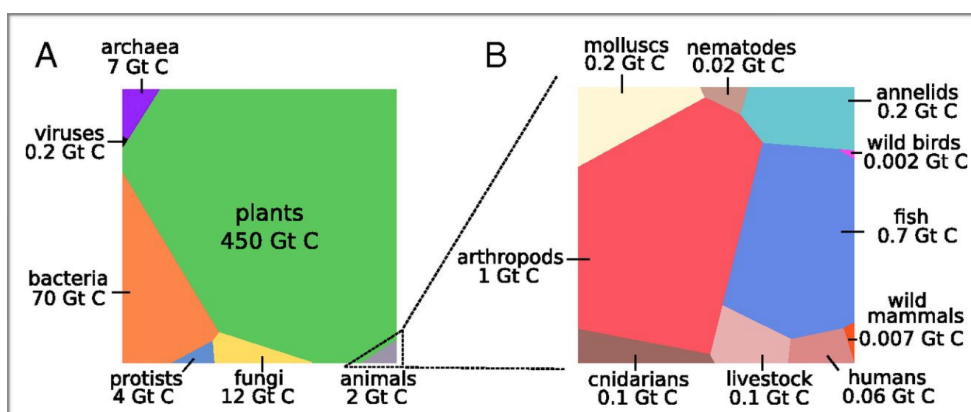


Figure 3.

<sup>258</sup> IPCC. About, History of the IPCC. (Last visit 27/04/2023). <https://www.ipcc.ch/about/history/>

<sup>259</sup> IPCC. About, The Reports. (Last visit 27/04/2023). <https://www.ipcc.ch/about/history/>

<sup>260</sup> Y. M. BAR-ON, R. PHILLIPS, R. MILO. 2018. *The biomass distribution on Earth*. Proceedings of the National Academy of Sciences, 115(25), 6506-6511.

*Graphical representation of the global biomass distribution by taxa. (A) Absolute biomasses of different taxa are represented using a Voronoi diagram, with the area of each cell being proportional to that taxa global biomass. (B) Absolute biomass of different animal taxa.<sup>261</sup>*

While they are alive, they absorb CO<sub>2</sub> from the air and combine it with water to grow, while releasing oxygen, thanks to the solar energy (photosynthesis). Through this process they can store much of the carbon in their cells, while at the time of their death most carbon is released back into the environment. They can alter the local climate on a short time scale or a longer term scale. For instance, the shortest term scale can be seen annually in the Northern Hemisphere, where it is possible to witness a seasonal oscillation of carbon reduction and emission in the atmosphere. The reduction is connected to the vegetation phase of growth from spring to summer (photosynthesis) and the emissions are connected to their dormant phase during autumn and winter in which annuals die out and deciduous trees lose their leaves (oxidation).<sup>262</sup>

Plants are also connected to the water cycle through the transpiration phenomenon (the ability of plants to return part of the water they absorb from the soil, back to the atmosphere). In a way, they can contribute to the maintenance of local humidity through a positive feedback: the more consistent the precipitation, the more forests can grow and expand and increase the transpiration of water vapor, adding to the amount of precipitation. On the contrary, bare soils have very little water retention and transpiration capacity, thus the drier it gets, the less the precipitation and the less possibility for plants growth.<sup>263</sup>

Yet, plants can also become long term storages. In particular, the fossil fuels that we are burning today are actually fossilized plants dating back to around 300 million years ago (carboniferous period), in the case of coal, and more than 66 million years ago in the case of oil.<sup>264</sup> Those are very long term storages of carbon, which we are releasing out in the atmosphere by burning it as an energy source.

Even without going that far back in time, wetlands and forests can have a very long life and they currently contribute to maintaining a healthy balance of carbon out of the atmosphere. Yet,

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<sup>261</sup> BAR-ON, PHILLIPS, MILO. 2018. *The biomass distribution on Earth*. Proceedings of the National Academy of Sciences, 115(25): 6506-6511. Figure 1.

<sup>262</sup> RUDDIMAN. 2014. *Earth's Climate*. p.51

<sup>263</sup> RUDDIMAN. 2014. *Earth's Climate*. p.52

<sup>264</sup> National Geographic. 2019. *Fossil fuels, explained*. Christina Nunez. <https://www.nationalgeographic.com/environment/article/fossil-fuels>

the plants' capability to absorb carbon and grow is strictly connected to their health. The more the stresses, the less the growth. Thus, an unhealthy forest might be very poor at compensating the CO<sub>2</sub> emissions released by humans for instance. And agricultural crops have an incredibly short life-cycle which does not store carbon for long at all.

Last but not least, the removal and alteration of natural forest cover for agricultural purposes is believed to be the original cause of CO<sub>2</sub> increase in the atmosphere since the early times in human history according to the early anthropogenic hypothesis.<sup>265</sup>

To cut it short, by taking in consideration how much a single element as vegetation can have an effect on other spheres, I hope it helps to see how complex the Earth is, with many more elements causing reactions with each other in the never-ending cycle of life.

Moving back to the IPCC, with the passing of the time naturally the research in the climate field has been impressively improving and, as previously mentioned, with more and more consensus it was agreed that humans were in fact responsible for this climate change.

The main issue that is causing an imbalance in the system is the excessive release of carbon in its gaseous form (i.e. CO<sub>2</sub>, CH<sub>4</sub>) in the atmosphere, which results in powerful greenhouse gases trapping too much of the Earth's outgoing radiation and causing an internal warming. This warming has several consequences that reinforce the future warming, for instance, the melting of glaciers and snow covers (which have a higher ability to reflect energy rather than absorb it). The anthropogenic activities that cause the release of carbon are related to energy consumption (i.e. fossil fuels burning), changes in land use and unsustainable land uses (i.e. urbanization, forest clearing, land exploitation through plantations, pollution, etc.), and social factors connected to unsustainable lifestyles, including overproduction and consumption.<sup>266</sup>

Since the early IPCC report publications, the international community was posed in front of the huge and difficult task to find a way to come to terms with a possible climate change, both in terms of adaptation to it and mitigation of the phenomenon. Each with different degrees of success and involvement, there have been few major international meetings such as the Summit in Rio (1992), which led to the creation of the UNFCCC (United Nations Framework Convention on Climate Change) and the beginning of official Conferences of the Parties (COP) on the topic. The most relevant COPs since then have been the one in Kyoto (COP3) in 1997 and the one in Paris (COP21) in 2015.<sup>267</sup>

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<sup>265</sup> RUDDIMAN. 2014. *Earth's Climate*. p.329-331

<sup>266</sup> IPCC. 2023. *Climate Change 2023: Synthesis Report*. p.10

<sup>267</sup> UNFCCC. About us. About the Secretariat. (Last visit 25/04/2023). <https://unfccc.int/about-us/about-the-secretariat>

Regardless of these COP being considered a partial failure and a great success respectively, the reality remains that we have not been able to stop, let alone invert, the current trends yet. Indeed, the target established by the Paris Agreement of trying to limit global warming to 1,5°C higher than the pre-industrial period, within 2°C at worst, seems like a less and less achievable goal the more the years pass. According to the latest AR6, future scenarios based on current emission trends show a possible global warming of 3.2 [2.2-3.5]° C by 2100 and only a fast and extreme change could help limit the peak to 1.4°C warming, such as reaching a global net zero emissions by 2050.<sup>268</sup>

As pointed out at the beginning of this section, mutability is part of nature and by being ourselves part of nature, there is nothing wrong per se in changes to happen. Yet, most of us will agree that we are definitely not prepared for a change this big, especially at the speed that we are experiencing. Humans, as well as the majority of the living beings on Earth, might not be able to adapt to the exponential effects of a fast global warming.

The negative side effects of global warming are already impacting human and natural landscapes and processes, and this transition phase is especially dangerous because of its unpredictability. Extreme weather events like tropical cyclones and floods are more frequent and intense, due to sea level rise started by the melting of glaciers and sea thermal expansion. The temperature increase is not all, the oceans are also becoming more acidic, causing stress and high mortality rates on coral reefs and marine life. While on land desertification is advancing fast and is rising the risk of wildfires, tree mortality and even diseases can spread easier. For both marine and terrestrial ecosystems the seasonal timings are going out of phase and many plants and animal species are shifting towards higher latitudes and altitudes because their normal distribution ranges are now becoming too warm and unsuitable, which means that biodiversity is either struggling for adaptation or is being lost.<sup>269</sup>

An incredible number of damages and losses are also undergoing for man-made infrastructures and societies: decreased food and water security, economic losses, increased political instability, urban heat waves, displacement, health and mental health hazards, and much more...<sup>270</sup>

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<sup>268</sup> IPCC. 2023. *Climate Change 2023: Synthesis Report*. p.33

<sup>269</sup> IPCC. 2022. Summary for Policymakers. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the IPCC. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-33. p.9-II.

<sup>270</sup> *ibidem*

Lastly, what can be most unsettling is the possibility of worsening long term adverse effects, since the breach of the threshold of 1.5°C warming could result in some irreversible changes (i.e. permafrost thaw, glaciers melt, coral reefs annihilation, mass species extinction).<sup>271</sup>

After all these global scale considerations, we might ask ourselves: what about Italy? What can we say about climate change and its effects on a more regional or local level?

Looking at the AR6 on Impacts, Adaptation and Vulnerability, the IPCC has specific chapters dedicated to each global region. For what concerns Europe, in particular, there have been 4 key risks identified related respectively to heatwaves, agricultural production, water scarcity and floods.<sup>272</sup>

Moreover, unfortunately the risks are considerably higher for Southern Europe, compared to Northern regions,<sup>273</sup> as shown in Figure 4, which focuses on heat stress for the European population for the period 2040-2060 according to 3 different future scenarios of global warming.

From these projections, it is possible to see how high are the risks for the Southern European populations in the Mediterranean area. In fact, the Mediterranean, in which Italy lies, is a region characterized by unique biocultural features, which makes it very sensitive to climate changes.

First of all, a major threat is sea level rise, which during the 20th century has risen by 1,4 mm per year on average in Mediterranean sea; the high population density, the numerous settlement and the economic production located in coastal areas make even a sea level rise of less than a meter incredibly dangerous in the countries on the Mediterranean coasts.<sup>274</sup>

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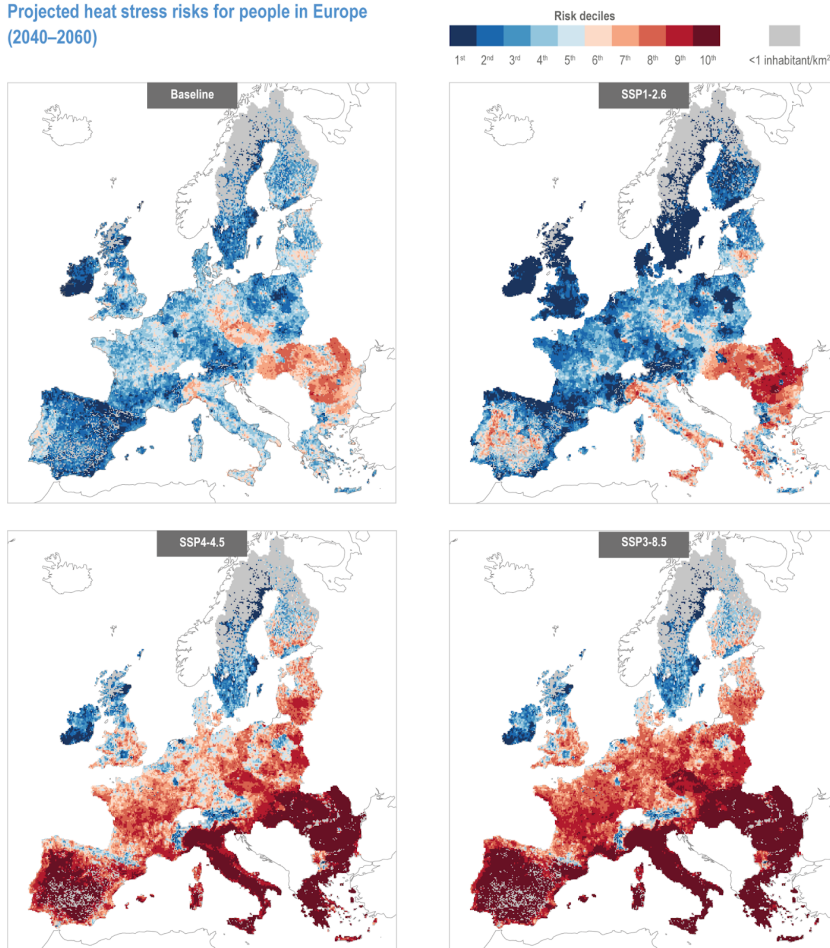
<sup>271</sup> IPCC. 2022. Technical Summary. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 37-118. p.69

<sup>272</sup> IPCC. 2022. Chapter 13, Europe. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1817-1927. p.1819

<sup>273</sup> IPCC. 2022. Chapter 13, Europe. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. p.1820

<sup>274</sup> IPCC focal point for Italy. 2022. *Il rapporto IPCC spiegato dagli esperti italiani con i contenuti principali su Europa, Mediterraneo e Italia*. P. Lionello, G. Naumann. <https://ipccitalia.cmcc.it/il-rapporto-ipcc-spiegato-dagli-esperti-italiani-con-i-contenuti-principali-su-europa-mediterraneo-e-italia/>

Projected heat stress risks for people in Europe  
(2040–2060)



**Figure 4.**

*Scenario matrix for multi-model median heat stress risks for the baseline 1986-2005, and different SSP-RCP combinations for the period 2040-2060.*

*Heat stress risk is calculated by geometrical aggregation of the hazard (heatwave days), population vulnerability and exposure.<sup>275</sup>*

Secondly, the high temperatures are putting under increasing pressure the water resources of the Mediterranean region, struck by more and more dry periods, droughts and wildfires. This phenomenon turns into a feedback loop in dry climates as anticipated by the earlier example of the relationship between vegetation and climate: the high temperatures and the low precipitation influence the vegetation, forests eventually retreat in favor of grasslands, which reduces water vapor transpiration and the general evapotranspiration because the soil is less and less able to absorb much water as it becomes poorer and this adds up to the drying of the climate.

Aridity and less predictable precipitation patterns consequently increase the water needs and the IPCC predicted that 18% of the population of Southern Europe will suffer from water scarcity with an increase in global temperature of 1,5°C, which can turn into 54% in the case of a 2°C increase.<sup>276</sup>

<sup>275</sup> Figure 13.22 in IPCC. 2022. Chapter 13, Europe. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA. pp. 1817-1927. doi:10.1017/9781009325844.015.

<sup>276</sup> IPCC. 2022. Chapter 13, Europe. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. p.1828

Naturally, Italy is already particularly suffering from all of these angles. The average temperature anomalies are increasing in line with global trends, with a gradient of +0,38 [+/- 0,05]°C every 10 years (1981-2019 period), with particularly higher occurrence of extremes during summer.<sup>277</sup> The prolonged and intense heat waves have also been higher than average from 1996 onwards and are expected to be more and more numerous in the future.<sup>278</sup>

Meanwhile, the projections on the precipitation are less easy to determine, but there could be a slight decrease (-1,5% overall precipitation) [variation range between -8% and +5%] in the 2061-2090 scenarios. Even if that number does not seem frightening, it is certain that the precipitation patterns are becoming less frequent and more intense, making water management a serious issue.<sup>279</sup> In turn, coupled with the sea level rise, this will increase hydrological instability, the soil erosion, and the desertification risks of already semi-arid areas (especially Southern regions of Italy and the islands).

The effects are major not only on populations but on the economy of a country famous for its agricultural high quality production and its fishery and seafood, not to forget the impact on tourism and the cultural heritage of Italy. In particular, agricultural losses are higher in areas where the fresh waters are being salinated due to the combined effect of droughts and the intrusive effect of the sea.<sup>280</sup> And the fishery, which is being affected by the rising sea temperatures, is already showing signals of change due to the appearance of alien species adapted to warmer waters in our seas (such as the lion fish, *Pterois volitans*, and the blue crab, *Callinectes sapidus*).<sup>281</sup>

But Italy not only presents Mediterranean environments, it also includes alpine environments in the Northern regions. This makes it doubly vulnerable to climate changes: alpine environments undergo changes much faster than other environments during global warming.

The permafrost of the West Alps is being degraded and the 6 glaciers studied by the SNPA (Sistema Nazionale per la Protezione dell'Ambiente) are all subjected to a considerable melting of ice: between 1995 and 2019 the loss of equivalent water ranged from a minimum of 19 m at the Basòdino glacier to a maximum of 41 m at the Caresèr glacier.<sup>282</sup>

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<sup>277</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici - Ed.2021*. Report SNPA 21/2021. p. 31

<sup>278</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici*. p.32

<sup>279</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici*. p.33

<sup>280</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici*. p.41-42

<sup>281</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici*. p.172

<sup>282</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici*. p.14-15



The fauna and flora are incredibly sensitive and many of them are already moving in altitude to maintain their habitat requirements, but many will likely become extinct if the warming continues because there would be no more a suitable environment for them to find.

Another relevant issue for Italy is the high population density, condensed in urban areas, especially in the Northern regions; when urban environments are subjected to heatwaves, they incur in the heat island effect, which means that roads, pavements and similar man made infrastructures absorb more heat compared to natural environments. This can pose serious complications for the population health, especially when the heat waves become prolonged and more intense, while the sanitary system is less and less able to keep up with the needs of an aging population.<sup>283</sup>

All these factors are combined and amplified in the Po Valley area of Northern Italy due to its peculiar geophysical morphology, which traps the airflow (as well as polluting particles in the atmosphere)<sup>284</sup>, and the growing trends in land consumption for urbanization purposes.<sup>285</sup>

It is time to acknowledge that Italy is a country incredibly sensitive to climate changes and natural instability; we used to think that the worst consequences of climate change would not terribly impact the European continent, but this is not the case and even if it is not the worst impacted area of the world, real deep changes are occurring. As it is proved by the 12 billion euros of EU damages in the year 2020 for climate-related events, and 145 billion for the last decade (2010-2020).<sup>286</sup>

After this incursion inside the topic of climate change and its impacts, it is time to start delving into positive strategies to counteract it. The following section will analyze the connection between botanic gardens and climate change: the different opportunities that botanic gardens have to contribute to the global, national and local efforts to fight climate change and some examples of the adaptation strategies that have already been put in place.

### *3.2 The Reaction of Botanic Gardens*

It is true that the research in this field does not come with perfect answers, because it is based on very complex statistical models which cannot be reproduced in a laboratory, thus, there will

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<sup>283</sup> SNPA. 2021. *Rapporto sugli indicatori di impatto dei cambiamenti climatici*. p.40

<sup>284</sup> ISPRA. 2023. *Ambiente in Italia: uno sguardo d'insieme. Annuario dei dati ambientali 2022*. Stato dell'Ambiente 100/23. Roma, Italia. p.138-139-140

<sup>285</sup> ISPRA. 2023. *Ambiente in Italia. Annuario dei dati ambientali 2022*. p.257

<sup>286</sup> Eurostat. (24/10/2022). *Losses from climate change: €145 billion in a decade*. <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221024-1>

always be a possibility for error over the predicted future scenarios. However, the direction we are going toward is indisputable, so instead of pursuing arrogant habits that we know are altering the natural equilibriums of the Earth, let's focus on the things that we can actually work on to be better.

The actions that can be put in place are generally divided into adaptation and mitigation actions; mitigation aims at limiting the worsening of climate change, such as reducing GHGs emissions, while adaptation aims at reducing the risks connected to the changes that are already undergoing and that will happen in the future, like making urban environments more resilient to heatwaves and floods.<sup>287</sup> To simplify this in terms of individual actions, we can mitigate our impact on climate change by reducing the emissions related to our modes of transport (i.e. taking less flights, or biking instead of driving), but we can also adapt to the global warming by saving more water in our daily lives considering that it is becoming a resource more and more precious.

Both mitigation and adaptation actions are strongly necessary, since there is a “committed warming” of the planet that will occur no matter the current cut in emissions due to a slow reaction of some elements of the Earth's system, such as the deep oceans, which will not become apparent for hundreds or thousands of years.<sup>288</sup>

In a time of instability and rising challenges such as this, what is most needed is cooperation at all levels, from all parts of the globe and society, from individuals to nations and organizations. In this context, botanic gardens have the opportunity to give a consistent contribution to the historical period we are living in because their role is very fluid and mutable: they can touch individuals at the local level, but they can also support regional and national efforts, as well as be heard by the international community.

Considering that it is not an easy task, we shall see what they can do in practical terms. Yet, we have to keep in mind that, due to the often limited size of botanic gardens, like the Botanic Garden of Bergamo which is only 3'000 square meters, most of them do not have a relevant power to combat climate change directly in terms of GHGs emissions (although any institution can give its small contribution in this sense). For this reason, most of the actions we will mention in this section are in a way indirect, and often focus on setting an example on social and educational aspects.

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<sup>287</sup> IPCC. 2023. *Climate Change 2023: Synthesis Report*. p.18

<sup>288</sup> IPCC. 2021. Technical Summary. In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. Cambridge, United Kingdom and New York, NY, USA, pp. 33-144. p.39

On the other hand, even though they are generally limited (in size) controlled environments and predictions cannot tell in detail what will happen on such a local scale, botanic gardens do suffer from climate change side effects just as any other infrastructure.

For instance, an already vulnerable reclaimed area, such as the lower garden of the Royal Botanic Garden of Sydney, becomes even more at risk due to sea level rise and it undergoes regular flooding.<sup>289</sup> Moreover, in many countries around the world, the increase of droughts is posing higher risks of wildfires (or the spread of human caused fires) which, combined with the poor infrastructural systems of some gardens, results in tremendous damages. One case like this is represented by the Yerevan Botanical Garden in Armenia, which has the possibility to cover only 40% of its 80 hectares with a proper irrigation system and in 2019 was hit by a wildfire that started in a high risk area that hosts a collection of dry-land shrubs and trees, causing the loss of 4'000 individual specimens.<sup>290</sup> Last but not least, there are also cases in which extreme events are simply becoming more and more frequent causing a chain of stressful events. The most striking example is the Botanical Garden of the Vilnius University, that from 2017 onwards experienced one year after another a late frost, a drought, floods and heavy snow to complete the biennial COVID19 pandemic emergency.<sup>291</sup>

This said, it is time to delve into positive actions that have been taken and can be taken by botanic gardens.

First of all, as anticipated in the first chapter, modern botanic gardens can themselves be sustainable institutions. And we know that climate activism is intrinsically connected to sustainability. In fact, in the same year of the famous COP21 in Paris (2015), not only was it reached the Paris Agreement on climate change, but also the 2030 Agenda for sustainable development.<sup>292</sup>

Although there is still criticism over the fact that the concept of sustainable development does not revolutionize the current society's pillar values which led us to the current global crises, the SDGs (sustainable development goals) are with no doubt a positive guide towards better goals and practices for a more equilibrated society, economy and environment.

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<sup>289</sup> J. GRATZFELD, P. SMITH, N. ÁLVAREZ DE ROMÁN. 2021. *The susceptibility of botanic gardens, and their responses, to natural and man-made disasters*. BGCI, Richmond, UK. p.19

<sup>290</sup> GRATZFELD, SMITH, ÁLVAREZ DE ROMÁN. 2021. *The susceptibility of botanic gardens, and their responses, to natural and man-made disasters*. p.12

<sup>291</sup> GRATZFELD, SMITH, ÁLVAREZ DE ROMÁN. 2021. *The susceptibility of botanic gardens, and their responses, to natural and man-made disasters*. p.7

<sup>292</sup> UN. Sustainable Development. *The 17 goals, History*. (Last visit, 9/05/2023). <https://sdgs.un.org/goals>

The interests of botanic gardens are often already in line with the sustainable goals (public awareness, education, plant research and conservation, horticulture support...). According to a survey conducted by the BGCI, at least one of the SDGs or more are among the priorities of 65% of the institutions contacted (especially, SDG4: quality education, and SDG13: climate action).<sup>293</sup>

Botanic gardens have a great array of possible mitigation and adaptation actions they can perform within their main areas of work, and, as institutions, they can set an example on a local scale.

On the topic of energy consumption, several botanic gardens are trying to lower their levels, switching to renewable energy sources and offsetting their carbon emissions, as for the Phipps Conservatory and Botanical Gardens in Pennsylvania, USA, mentioned in Chapter I. They invested much in implementing a change by using a tool that calculates the carbon footprint of the botanic garden and Conservatory and the money that would be necessary to offset it were invested in solar panel for the research campus,<sup>294</sup> and they also created an avant-garde Center for Sustainable Landscapes (CSL) that is fully net-zero energy. Yet they did not stop there, they wanted to promote positive behavior in visitors as well, inviting them to switch their energy provider through a partnership with GME (Green Mountain Energy).<sup>295</sup>

Indeed, since botanic gardens have a wide audience they have a role in spreading information and recommendations. The Botanical Garden of Gothenburg, for instance, gives several inputs to its staff to reduce their emissions both in their private and working life, for example, by taking part to the “Bicycle friendly workplace”; this initiative does not simply inform the employees of benefit of biking instead of traveling by car, but implements structural ameliorations to support people who would choose this option, such as a dedicated roofed bike parking and changing rooms equipped with showers.<sup>296</sup>

Another topic often touched by sustainable development is waste management, in an optic of shifting from a linear to a more circular economy. The reduction of waste might seem not as relevant as carbon emission reduction, but when considering that it could mean a more efficient use of water, food and resources, as well as the demonstration to people that similar practices can be applied by everyone, then it is clear how much relevant it actually is. And this is a priority in many botanic gardens.

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<sup>293</sup> BGCI. 2020. *The role of botanic gardens in practising and promoting environmental sustainability*. BGCI Technical Review. p.7

<sup>294</sup> BGCI. 2020. *The role of botanic gardens in practising and promoting environmental sustainability*. p.19

<sup>295</sup> BGCI. 2020. *The role of botanic gardens in practising and promoting environmental sustainability*. p.16-17

<sup>296</sup> BGCI. 2020. *The role of botanic gardens in practising and promoting environmental sustainability*. p.18

Rainwater collection, efficient irrigation systems and reuse of water will turn the demand for precious water to a minimum. The Botanic Gardens of Auckland, New Zealand, has put in practice several innovative ideas for a more sustainable use of water. Rainwater is collected through roofs or living roofs and then stored underground, so that it can be then reused for watering the collections, but also in some cases for fountains and for the toilets of the Visitors Center. The living roofs also have the double function of reducing the runoff in case of storms, since it can absorb up to 65% of the water. Moreover, they studied which plants can function as natural treatment for rainwater and created some rain gardens, which reduce possible pollutants coming from car exhausts or general air pollutants; said plants were also used within lakes, contributing to purifying the water that eventually will be absorbed by the soil or flow into local streams. This technique is called riparian planting and clarifies how actions within a botanic garden can contribute to local support to infrastructures and biodiversity even outside of their official domain.<sup>297</sup>

Likewise, reusing materials and composting will reduce the costs of waste management, as well as the demand for new resources, which in turn means less energy is required to produce these resources upstream. The daily maintenance of gardens includes a lot of plant waste, however, this does not mean it has to be thrown away; the simplest way of recycling is to include a recycling or compost station to return plant waste first into compost and then to the soil, fertilizing it, as it was done by the Shanghai Botanical Garden, China, (which processes enormous quantities of green waste, up to 40'000 tonnes a year). Moreover, this action not only can become an educational activity, but it can directly support citizens. For instance, the Botanical Garden of the University of Fribourg, Switzerland, decided to take local composting into its own hands, since the closest facility to turn food waste into compost was outside the city and not very convenient for the locals. Naturally, the resulting compost is used as fertilizer for the garden collections.<sup>298</sup>

Indeed, several botanic gardens have started to realize that they can teach much about food production and food waste. As mentioned in Chapter 2, the Botanic garden of Bergamo has been promoting this theme along with its activities and projects (such as Big Picnic or Increase) for decades, as well as through the creation of the Biodiversity Valley in Astino dedicated to alimentary plants.

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<sup>297</sup> Auckland Botanic Gardens. About us. Sustainable water management. (Last visit 13/05/2023). <https://www.aucklandbotanicgardens.co.nz/about-us/our-policies/sustainable-water-management/>

<sup>298</sup> BGCI. 2020. *The role of botanic gardens in practising and promoting environmental sustainability*. p.23-24

We shall not forget that botanic gardens were born with the intent of educating. And since education and research are adapting to the current most urgent topics, even in the matter of climate change botanic gardens have much to teach.

In some cases it can result in general public education open to all, independently from their age or background, like the online course *Plants and climate change* developed by the Royal Botanic Garden of Edinburgh.<sup>299</sup> The course is a useful tool for self-paced but guided learning (which I also personally completed in these months), to better understand the relationship between the phenomenon of climate change and plants, and how they influence each other. The possibility of benefiting from a completely free online resource is very important in terms of spreading public awareness and making easier and more accessible relevant information. Indeed, for many people, approaching this enormous topic can be confusing and the world wide web is rich in information, yet not always correct or even contradictory; official educational institutions have the duty to clear the air from confusion and contradictions, to better communicate the notions that scientists agree upon.

In other cases, botanic gardens can contribute to educating highly specialized figures in the matters of biodiversity conservation and adaptation to climate change. And they are well suited for this role since they can be used as monitoring stations all year round; already in the 19th century some colonial botanic gardens were used as meteorological bases in a way, since it was required of curators to take measurements every day, among the many duties they had.<sup>300</sup> Even if today the main objectives are different and technical equipment is more advanced and precise, botanic gardens have been helping in monitoring both the weather conditions changes over the years and the response of plant specimens to said variations for longer than we imagine. And they can certainly make this their strength. For instance, the Botanical Garden of Cartagena, Colombia, is in charge of managing a protected forest area (of 9 hectares) a few kilometers away from the city. Within this protected area it was created a permanent forest plot both as a living experiment and an opportunity to raise awareness. In here, are carried out analysis of the ecological structure and composition of the area, as well as its carbon stock capability. University students can be trained in the techniques used to gather these data and, at times, even visitors can be guided in this living laboratory to understand the importance of research and monitoring.<sup>301</sup>

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<sup>299</sup> Royal Botanic Garden Edinburgh. Learn. Online Courses, Plants and Climate Change. (Last visit 13/05/2023). <https://www.rbge.org.uk/learn/online-courses/plants-and-climate-change-course/>

<sup>300</sup> MCCracken. 1997. *Gardens of Empire*. p.92-93

<sup>301</sup> BGCI. 2021. *Botanic Gardens and Climate Change Education*. *Roots*, 18(1): 1-43. p.14-16.

Monitoring is not the only way for botanic gardens to support biodiversity: the most classic actions, of which many botanic gardens are most proud of, regard *in situ* and *ex situ* conservation. This literally means protecting species in their natural habitats (*in situ*) and, when it is not possible, outside of them (*ex situ*), within specifically designed structures that can host specimens for future studies or for future reintroductions in natural environments.

Another infrastructure very relevant for this purpose are seed banks, such as the Svalbard Global Seed Vault; as the name suggests, seed banks do not conserve living plants in a classic way, but are able to preserve genetic material in a dormant form (that of the seed), thanks to the peculiar plant feature that is to survive for years and even for centuries in that state until the right conditions for germination arise. In some rare extreme cases, seeds have survived even longer than that, as for the *Silene stenophylla* seeds that were found in 2012 in Siberia, buried under 38 meters of permafrost since the Ice Age (32'000 years old), and that still contained enough living material to regenerate a specimen.<sup>302</sup>

All of these interesting actions have become much more relevant in these years due to the harder impacts that biodiversity is experiencing consequently of climate change. In fact, other than the now unfortunately classic threats to biodiversity (i.e. habitat loss, invasive species, pollution, over-harvesting), there is now a far more dangerous strong and fast climate change undergoing. Why is this bad news? If you remember, plants are influenced by climate. All plants around the globe have developed within specific biomes, adapting to the climatic conditions of those biomes. If the climatic conditions change, plants might not be able to thrive anymore in a specific area. Such an eventuality does not necessarily mean that plants have no way out and are all doomed to extinction. Contrary to general beliefs, plants are not immobile, they do move and they can even migrate, but it is not as obvious as animal migrations.

A practical example will be helpful to visualize it better. In a recent study, it was taken the Himalayan blue poppy (genus *Meconopsis*) as the perfect object of study for a range shift in distribution over time due to climatic variations. Alpine species are often very localized and specialized, and several species of Himalayan poppy (around 60) are endemic to the Himalayan-Hengduan Mountain region. When temperature rises, glaciers retreat and, within some generations, plants have more areas to colonize through root development as well as seeds

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<sup>302</sup> Rachel KAUFMAN. 2012. *32,000-Year-Old Plant Brought Back to Life- Oldest Yet*. National Geographic News. <https://www.nationalgeographic.com/science/article/120221-oldest-seeds-regenerated-plants-science#:~:text=A%20Russian%20team%20discovered%20a,seeds%20were%2032%2C000%20years%20old>

dispersal.<sup>303</sup> In this study it was accumulated information on the mean distribution of seven species of Himalayan poppy, putting in comparison historical data obtained from herbaria and modern observations *in situ*. Since there has been a relevant increase of temperature from the 1970s, the year 1970 was used as a dividing line between two periods: pre-1970s (1922-1969) and post-1970s (1970-2016). Between these periods it has been found a mean range shift of about 300 meters upwards (altitude), from 3'826,8m (+/- 561m) pre-1970s to 4'129,1m (+/- 548,2m) post-1970s, considering all the seven species examined.<sup>304</sup>

Naturally, this migration is expected to continue in future scenarios, both higher up in altitude and latitudes,<sup>305</sup> plants will always migrate to find better climatic conditions. However, the changes are happening too fast for all plants to adapt and when some habitat is lost, some newer spaces might open, but that is not always the case. At times a population might simply be destined to end there.

In relation to this, because both natural and man made barriers are multiplying, world's seed banks are increasingly necessary as a tool to implement reintroductions in the wild and the so-called "assisted migration" of plants, which attempts at creating man-made migratory corridors for the perpetuation of species at risk.<sup>306</sup>

Nonetheless, behind every action there can be both light and darkness. What can be used for a positive goal, can also be exploited. For instance, Xan Sarah Chacko presented a critique to seed banks for their inefficiency at times at preserving old seeds and their misplaced focus on constantly creating new collections, which can perpetuate extractivism and necropolitics. This is damaging especially for Indigenous populations from which seeds are collected, recalling colonialism, even if under the safe cover of biodiversity conservation goals.<sup>307</sup>

Indeed, seeds, just as well as plants, are not objects; they carry cultural and social values, they exist in relations with humans and, thus, preserving them out of their context strips them away of these relations and traditions that might get lost forever even in the case of plant species

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<sup>303</sup> X. HE, K.S. BURGESS, X-F. YANG, et al. 2019. *Upward elevation and northwest range shifts for alpine Meconopsis species in the Himalaya-Hengduan Mountains region*. Ecology and Evolution. 9: 4055-4064. p.4056.

<sup>304</sup> HE, BURGESS, YANG, et al. 2019. *Upward elevation and northwest range shifts for alpine Meconopsis species in the Himalaya-Hengduan Mountains region*. p.4058.

<sup>305</sup> HE, BURGESS, YANG, et al. 2019. *Upward elevation and northwest range shifts for alpine Meconopsis species in the Himalaya-Hengduan Mountains region*. p.4061

<sup>306</sup> David BRAMWELL. 2007. *The Response of Botanic Gardens to Climate Change*. BGJournal, 4(2): 3-8. p.5-6

<sup>307</sup> Xan Sarah CHACKO. 2022. *Stringing, Reconnecting, and Breaking the Colonial 'Daisy Chain': From Botanic Garden to Seed Bank*. Catalyst: Feminism, Theory, Technoscience, 8(1): 1-30. p.4-5



preservation. About this topic much has been written, for instance by Kristina Lyons, in her *Vital Decomposition*, where she highlights the importance of preserving cultural identity through agricultural traditions and, thus, indigenous seeds opposed to commercial seeds.<sup>308</sup>

Although these considerations should not become an obstacle to the actions in support of biodiversity, especially since the urgency of the times, they must help us in becoming more aware of possible negative cycles that we are unconsciously repropounding in modern times. Keeping this in mind, new possibilities open up for a better and more sustainable future, both socially and environmentally, of botanical institutions and related structures for conservation of the flora in all its forms.

Before reaching the conclusion of this 3.2 section, the key areas of action for botanic gardens in the 21st century that we have seen can be summed up as accumulation of information,<sup>309</sup> in order to understand local or regional needs and be part of the political round table over environmental and sustainable topics, inspiring and communicating research findings to the wider public, educating both the general audience and specific skilled figures for improved capacity building, and so on.<sup>310</sup>

Even though this might seem to encompass almost all that could be possibly thought for botanic gardens to enact, you will find that it is not so. In fact, I now want to introduce the Climate Change Alliance for Botanic Gardens (CCABG), which will lead us to the next and final part of this thesis, the Landscape Succession Strategy.

In very recent times, in 2018, at the very first Climate Change Summit for Botanic Gardens in Melbourne, Australia, it was signed by 13 botanical institutions the adherence to and creation of said CCABG, with the purpose of *growing and sustaining a global movement of botanic organizations that take action to protect and enable adaptation of botanical landscapes in a changing climate.*<sup>311</sup>

In other words, the new frontier of botanic gardens might be to do the opposite of what the first gardens were born for: instead of finding ways to use plants and techniques to recreate different climates out of context, they will adapt to a changing climate by using the plants that are better suited for said climate.

In fact, the use of plants to recreate other-worlds dates back to thousands of years BC; as we have seen in Chapter 1, the first grandiose sunken gardens of the neo Assyrian kings were an

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<sup>308</sup> Kristina M. LYONS. 2020. *Vital Decomposition: Soil Practitioners and Life Politics*. Duke University Press.

<sup>309</sup> BRAMWELL. 2007. *The Response of Botanic Gardens to Climate Change*. p.6

<sup>310</sup> S. KRISHNAN, A. NOVY. 2016. *The role of botanic gardens in the twenty-first century*. CAB Reviews, 11(23): 1-10.

<sup>311</sup> Royal Botanic Gardens Victoria. 2018. *Climate Change Alliance of Botanic Gardens Charter*. <https://www.rbg.vic.gov.au/media/iknn4jaw/climate-change-alliance-of-botanic-gardens-charter-full-version.pdf>

assortment of plant species coming from all corners of the empire and then used as representatives of far distant lands. And the increased ability of horticulturists allowed the creation of bubbles of alternate realities, each with its own microclimate.<sup>312</sup>

On the other hand, nowadays we recognize that there are macro climate changes that we cannot control and it is time to start adapting our choices to such changes in order to reduce our needs and vulnerabilities. And this is exactly what has been done at the Botanic Gardens of Melbourne, the first ever to develop and apply a landscape succession strategy,<sup>313</sup> which is renewing the gardens' landscape in order to cope with the future climatic conditions at the end of the century (2090), as well as other common issues within a botanic garden (i.e aging plants, water supply and biosecurity).<sup>314</sup>

In simplified terms, the strategy is very straightforward. First it is analyzed what are the most likely problems that will arise, or that will worsen with time (rising temperatures and lower rainfalls in the case of Melbourne). After that, the global current biomes and distribution maps of plants around the globe are used to better identify which species will be more at risk in the foreseen new conditions by the end of the century. In particular, by observing the range in temperatures and rainfalls that species normally fall into and the extremes out of which they cannot survive. Finally, after noticing a high number of specimens at high risk, they decided to modify the collections gradually between 2016 and 2036, so that by then most of the species of the living collections will be able to withstand the future climate of 2090.<sup>315</sup>

This project is meant to highlight how not only natural environments, but even man made landscapes are going to face considerable impacts due to climate change and that vulnerabilities are many. However, it can also represent an inspiring guideline for innovative approaches in terms of adaptation for botanic gardens all over the world, among which the interest in the topic is definitely growing if we consider that the CCABG has grown from its foundation in 2018 with 13 funding members to more than 400 members today.<sup>316</sup>

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<sup>312</sup> Annette GIESECKE. 2022. *A Cultural History of Plants* (Vol.1 In Antiquity). Bloomsbury Academic. p.159

<sup>313</sup> Royal Botanic Gardens Victoria. (Last visit 20/05/2023). Landscape Succession Strategy. <https://www.rbg.vic.gov.au/initiatives/landscape-succession-strategy/>

<sup>314</sup> Royal Botanic Gardens Victoria. 2016. *Royal Botanic Gardens Victoria, Landscape Succession Strategy - Melbourne Gardens 2016 - 2036*. Royal Botanic Gardens Board Victoria. p.4-5

<sup>315</sup> Royal Botanic Gardens Victoria. 2016. *Royal Botanic Gardens Victoria, Landscape Succession Strategy*. p. 23-29

<sup>316</sup> Royal Botanic Gardens Victoria. (Last visit 20/05/2023). Climate Change Alliance, Current Members. <https://www.rbg.vic.gov.au/initiatives/climate-change-alliance/current-members/>

### 3.3 Climate Assessment Tool applied in Italy

The Landscape Succession Strategy applied by the Royal Botanic Gardens Victoria in Melbourne, is most likely the first case in the world of an attempt of adaptation to climate change of a botanical living collection on such a large scale, while trying to preserve as well the cultural heritage value of the 177 years' old institution. The need for preservation of cultural heritage should not be underestimated, because since its creation in 1846, this botanic garden has become more and more a green landmark for the city, with the immense sum of 38 hectares and over 31 plant collections, many of which native to Australia.<sup>317</sup>

As you might have started to realize by the end of this thesis, real life is always more complex than the words we use to describe it and, whenever I explain something in simple words, there is a whole web of more intricate discourses that remain unspoken. For instance, the strategy in simple terms is clear, however, translated in practice it requires a lot more reasoning since the models based on general average data on temperature and rainfalls are not always faithful representations of all the local and seasonal variations that plants undergo in their habitats.<sup>318</sup> And an adaptation strategy to global warming is not just about removing trees and planting cacti; trying to respect the current organization of the garden and the use of native species is the real challenge.

Following this line, it is mandatory to have a critical eye when reading global charts and models. In the case of Melbourne, they saw similarities with north Africa, like some cities in Algeria or Morocco, but they tended to consider more analogies with cities of other Australian areas to avoid risking transferring species from too far distant lands and using others that could naturally migrate there, still reflecting the Australian rich biodiversity. In particular, among the cities that are expected to present similarities with Melbourne under a high emission future scenario (with average annual rainfall reductions of 9% and annual average temperature increases of 3°C) they found Cootamundra, Corowa, Cowra, Esperance, Forbes, Gawler, Keith, Parkes, Wagga Wagga, Wangaratta and West Wyalong.<sup>319</sup>

In the decision process for a successful landscape succession it is also important to keep in mind the power of microclimate: within the botanic garden itself there can be different temperature ranges. For example, in a central position of the Botanic Gardens Victoria there is the Fern Gully collection, which was reported to be 6°C cooler than the average Melbourne

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<sup>317</sup> Royal Botanic Gardens Victoria. (Last visit 27/05/2023). Melbourne, Discover Melbourne Gardens. <https://www.rbg.vic.gov.au/melbourne-gardens/discover-melbourne-gardens/>

<sup>318</sup> Royal Botanic Gardens Victoria. 2016. *Royal Botanic Gardens Victoria, Landscape Succession Strategy*. p.23

<sup>319</sup> Royal Botanic Gardens Victoria. 2016. *Royal Botanic Gardens Victoria, Landscape Succession Strategy*. p.23

temperature records during hot days (over 30°C).<sup>320</sup> That is why some plants that theoretically should not be fit for certain conditions do actually grow in gardens, because of microclimatic conditions that differ from the general urban ones. For the same reasons, green spaces are recommended within urban context, to limit the heat island effect of cities, as we have seen in previous chapters.

In other cases, aside from changes to the collections, some structural changes could also be applied to adapt the likely water stress of future scenarios, such as research on ‘water banking’ in the subsoil (storing water when possible to save it for a future moment of need).<sup>321</sup>

Other than considerations regarding inner problems, the strategy also involves cooperation with other institutions for the exchange of specimens. In fact, cooperation and communication between different localities helps understanding what to do with sensitive endangered species that can no longer be maintained in one place. Finding agreements with other botanic gardens to exchange them and find for them a better location ensures that they are not just removed and forgotten and, likewise, other gardens can provide the next generations of specimens for applying the succession strategy.

Last but not least, the gathering of information within reports, guidelines and articles regarding the strategy by the Royal Botanic Garden Victoria and the upload of said information on their webpage, in order to make it available for the members of the CCABG and the public, is definitely one of the most relevant actions. This is not only for reasons of spreading awareness, but for giving real support to whoever would like to reproduce the strategy in any other part of the world.

However, looking at the rest of the world there is not as much interest in it yet, as one would hope; through a standard research on the google scholar search engine I have not found other examples, with the exception of one, of published articles regarding other gardens using the Climate Assessment Tool or having decided to put in practice a similar Succession Strategy.

First of all, this type of study is still very recent and the succession strategy applied in Melbourne could be the first of its kind in the world, which means that it is an ongoing developing process and that the final results will be seen or assessed within a century from today. This could be a reason why many institutions have not yet recognized the benefits of such a long term planning adaptation action. On the other hand, I believe that more than this, it cannot be

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<sup>320</sup> T. J. ENTWISLE, C. COLE, P. SYMES. 2017. *Adapting the botanical landscape of Melbourne Gardens (Royal Botanic Gardens Victoria) in response to climate change*. *Plant Diversity* (39): 338-347. p.343

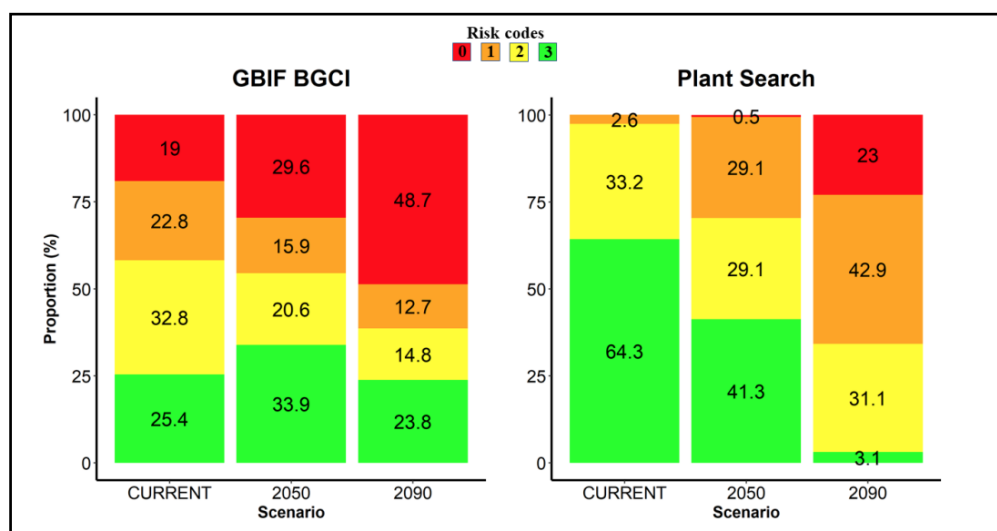
<sup>321</sup> ENTWISLE, COLE, SYMES. 2017. *Adapting the botanical landscape of Melbourne Gardens (Royal Botanic Gardens Victoria) in response to climate change*. p.344

underestimated that there are very few gardens in the world which have enough resources, both in economic and social terms (i.e. workforce, competences), to tackle such a systemic issue in an organic matter. From personal experience, I have noticed how often long term planning comes second in comparison of short term patching solutions.

Nonetheless, studies in this direction are likely to blossom in the next few years, considering how hot the climate change debate has become. In particular, I am glad to share that the one exception mentioned previously corresponds to a case in an Italian botanical institution, the Botanic Garden of Pisa.

The historical Botanic Garden and Museum of Pisa is part of the CCABG Members and participated in a survey in 2022 sent out by the Alliance in which it expresses its concerns about a lack of detailed and practical indications on how to protect plant collections from climate change consequences.<sup>322</sup>

Moreover, in March of this very year 2023, it became the first Italian institution to publish a study on the use of the Climate Assessment Tool (CAT) to study its arboreta collection in anticipation of future climate scenarios. They found out that there is the possibility that more than half of the tree species (61-65%) there displayed in the arboreta collection might not be suited for the future climate in 2090 in the case of the worst “business as usual” scenario (SSP3/RCP7.0 to 2090), as shown in Figure 5.<sup>323</sup>



**Figure 5.** Risk category frequencies (%) assessed through the two models (GBIF BGCI and Plant Search) for the trees cultivated in the Botanic Garden and Museum of the

University of Pisa. For each model, the current climate and the two scenarios (SSP2/RCP4.5 forecast to

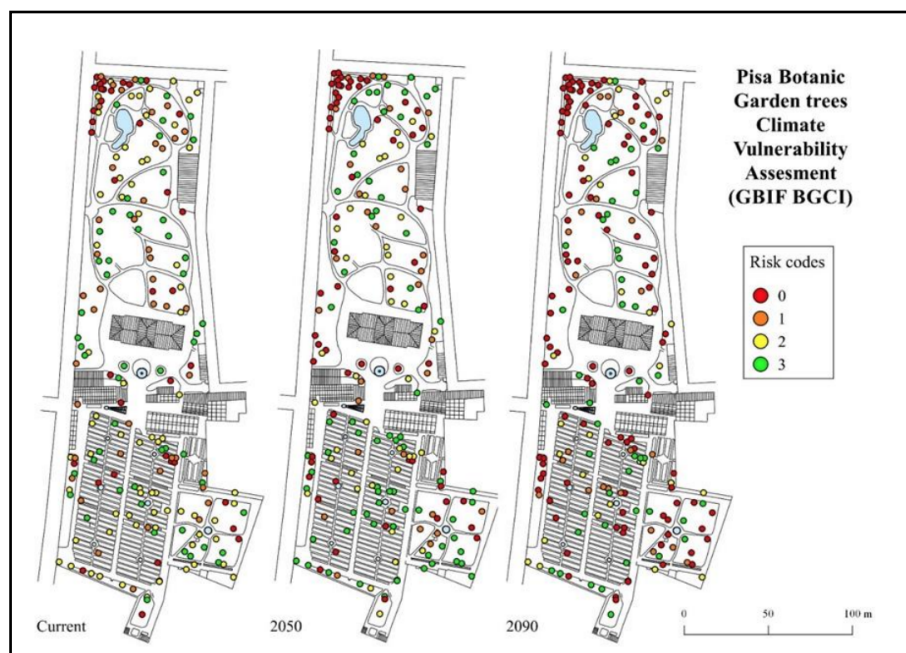
<sup>322</sup> Royal Botanic Gardens Victoria. (Last visit 27/05/2023). Climate Change Alliance, Current Members. Membership Survey.

<sup>323</sup> M. D'ANTRACCOLI, N. WEIGER, L. COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios: What Are We Walking into?*. Sustainability, 15, 4585. p.4

2050 and SSP3/RCP7.0 forecast to 2090) are contrasted. Risk codes vary along an ordinal scale from 3 to 0, with the extremes indicating a species known (risk code 3, in green) or not known (risk code 0, in red) to occur at the predicted mean annual temperature of the botanical garden's location.<sup>324</sup>

They had to make a selection of the specimens to be considered in the analysis due to lack of data or representation of certain cultivars or species in the BGCI and other related databases. The total number of trees analyzed are 213 individuals, belonging to 126 species and 42 families.<sup>325</sup>

It is evident that in the worse case scenario, SSP3/RCP7.0, the majority of trees will experience a worsening of their conditions (up to 95.9% will find themselves in worse conditions) and that it would be limited to a smaller percentage (from 36.5% to 49.0%) in the case of a more optimistic scenario with an emission cut SSP2/RCP4.5.<sup>326</sup> This can be more apparent when looking at Figure 6, which shows the mapped representation of the trees analyzed and their color coded associated risks.



**Figure 6.**

*Climate vulnerability assessment maps of the trees cultivated in the Botanic Garden of the University of Pisa, showing the risk categories according to an ordinal scale ranging from 0 (maximum risk) to 3 (minimum risk).*<sup>327</sup>

<sup>324</sup> D'ANTRACCOLI, WEIGER, COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios*. Figure 2. p.4

<sup>325</sup> D'ANTRACCOLI, WEIGER, COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios*. p.3

<sup>326</sup> D'ANTRACCOLI, WEIGER, COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios*. p.4

<sup>327</sup> D'ANTRACCOLI, WEIGER, COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios*. Figure 5, p.7

In their concluding remarks they also added observations on the reasons for being both optimistic and pessimistic over the results of the models, which are considerations that go further the simple data analysis, and work on the context of the collection. For instance, by being a garden in an urban context there are human induced stresses that would be less pronounced in a natural environment: higher temperatures due to the heat island phenomenon, risks for the soil health due the great affluence of visitors (60'000+ visitors per year in average), air or water pollutants, higher risks of contact with pests and pathogens, and so on. On the other hand, thanks to the collaboration of humans, the collection can be more preserved and controlled than natural environments; thus, proper horticultural techniques can improve the plants growth and cope with water stress and soil health.<sup>328</sup>

The study from Pisa will hopefully be the first of many, because much is still unknown about local needs and vulnerabilities of the Italian flora in its infinite declinations over the national territory. Researches that offer an overview of the general impacts expected on the Italian flora due to climate change are still very limited or too general, such as that published in 2017, which points out the poor knowledge of how climate change is transforming the species composition in warm temperate climates and the Mediterranean and, consequently, even less about the future changes in ecosystem functioning.<sup>329</sup>

The relevant findings that have a stronger basis are the rise in annual mean temperature over the entire national territory, and a reduction of precipitation in terms of occurrences, but a possible worsening of their intensity. The Alpine regions will undergo a stronger warming compared to other regions.<sup>330</sup>

The city of Pisa, close to the coasts of Tuscany, falls in the Mediterranean climatic zone, and the increase in temperatures could encourage plant growth, but the scarcity of water resources can cause severe droughts (especially in summer) or extreme events that will actually worsen the vegetation ability to thrive.

If we had to take in consideration Bergamo, the trends of temperature warming and reduced precipitation is confirmed here too, but the starting point is quite different due to its location.

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<sup>328</sup> D'ANTRACCOLI, WEIGER, COCCHI, et al. 2023. *The Trees of the Pisa Botanic Garden under Climate Change Scenarios*. p.8

<sup>329</sup> Stefano CHELLI, Camilla WELLSTEIN, Giandiego CAMPETELLA, et al. 2017. *Climate change response of vegetation across climatic zones in Italy*. *Climate Research*, 71(3): 249-262. p.258

<sup>330</sup> CHELLI, WELLSTEIN, CAMPETELLA, et al. 2017. *Climate change response of vegetation across climatic zones in Italy*. p.250

Dissimilarly from Pisa, the city of Bergamo lies in the North of Italy, at the northern margin of the Po Valley, before the pre-alpine environments, which makes it a city with a temperate climate.

Over the millennia, the territory of Bergamo and the surrounding valleys have experienced considerable climatic changes, and the expansion and reduction of the glaciers has determined important changes in the vegetation of these lands. Such as the melting of the glaciers that from their maximum expansion 30 thousands years ago, started retreating around 19 thousand years ago and led to floods and landslides, the formation of valleys (i.e. Adda, Brembo, and Oglio) and lakes (i.e. Gaiano lake) and the advance of pine forests higher up 1'700 metres (*Pinus sylvestris*, *Pinus mugo*, and *Pinus cembra*).<sup>331</sup> The lowland were characterized by dense forests of lime, elm, oak and silver fir trees; pre-alpine areas were dominated by lime, hazelnut and elm trees.<sup>332</sup> Then, around 8'000 years ago, the subsequent changes were influenced mostly by human activities, that through clearing fires for agriculture and pastures, reduced deciduous vegetation and allowed the spread of evergreen more resistant trees such as beech trees, which are more common today.<sup>333</sup>

As mentioned in Chapter 2, the original intentions of the creators of the Garden of Bergamo in 1972 were inspired by alpine gardens and to reproduce a botanic garden with alpine and pre-alpine flora. However, the changes in climate are such that the collection had to be modified consistently, not only for reasons of needs and scopes of the garden, but because many species are not suited to survive in a location of less than 300 meters altitude anymore, no matter the horticultural care. And this trend is likely to become more impactful with the decades, especially due to the mitigation of cold extremes during winter, the fewer snow precipitation occurrences and the anticipation of spring arrival.<sup>334</sup>

Inspired by the action of Melbourne, I decided to attempt a study similar to that of Pisa, but applied to the Botanic Garden of Bergamo. I extrapolated the list of species present at the Botanic Garden of Bergamo and selected those of which there is also information on the database of the BGCI CAT tool.

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<sup>331</sup> C. RAVAZZI, A. ACETI, M. DONEGANA, et al. 2007. *Il quadro ambientale del territorio bergamasco negli ultimi 130 mila anni: vegetazione, clima e uomo*. Storia Economica e Sociale di Bergamo, I: 237-247. p.241-242

<sup>332</sup> RAVAZZI, ACETI, DONEGANA, et al. 2007. *Il quadro ambientale del territorio bergamasco negli ultimi 130 mila anni*. p.242

<sup>333</sup> RAVAZZI, ACETI, DONEGANA, et al. 2007. *Il quadro ambientale del territorio bergamasco negli ultimi 130 mila anni*. p.245

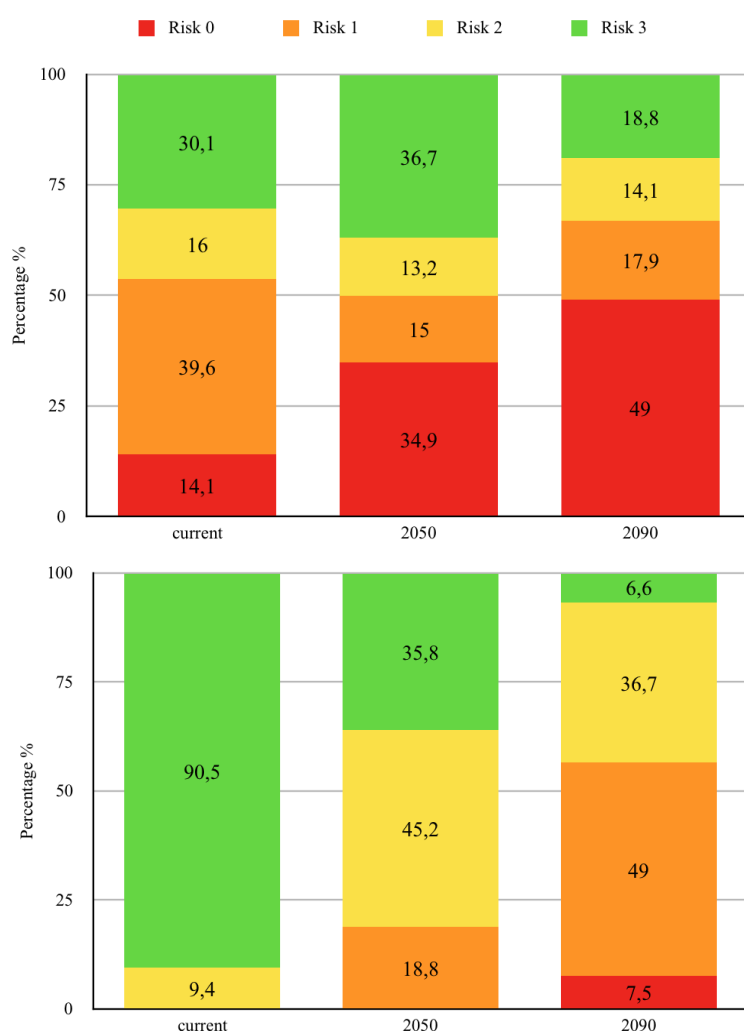
<sup>334</sup> CHELLI, WELLSTEIN, CAMPETELLA, et al. 2017. *Climate change response of vegetation across climatic zones in Italy*. p.251



Out of the 560 taxa digitally catalogued at the Città Alta Section, I analyzed 106 individual trees and shrubs, from 80 species, (Annex I for complete list). These are the taxa of which there was sufficient available information on the BGCI database to perform a forecast through the Climate Assessment Tool (CAT). Looking at Figure 7, it can be observed the preliminary results of how many of these selected species are more at risk of future climatic changes and which not.<sup>335</sup>

The risks are associated to the frequency of distribution of a species within a specific temperature range, which can be none (Risk 0) or optimal (Risk 3):

- Risk Code 0: species not known to occur at this temperature;
- Risk Code 1: at the edge of the known temperature for the species;
- Risk Code 2: species known to occur at this temperature;
- Risk Code 3: species mostly occurs at this temperature.<sup>336</sup>



**Figure 7.**

*Percentage of specimens divided by risk categories according to current conditions and two future predicted scenarios (SSP2/RCP4.5 forecast to 2050 and SSP3/RCP7.0 forecast to 2090). The upper graph is obtained through the model based on GBIF-BGCI records of species distribution in their natural habitats, while the lower graph is obtained from the model based on Plant Search records of species cultivated in Botanic Gardens.*

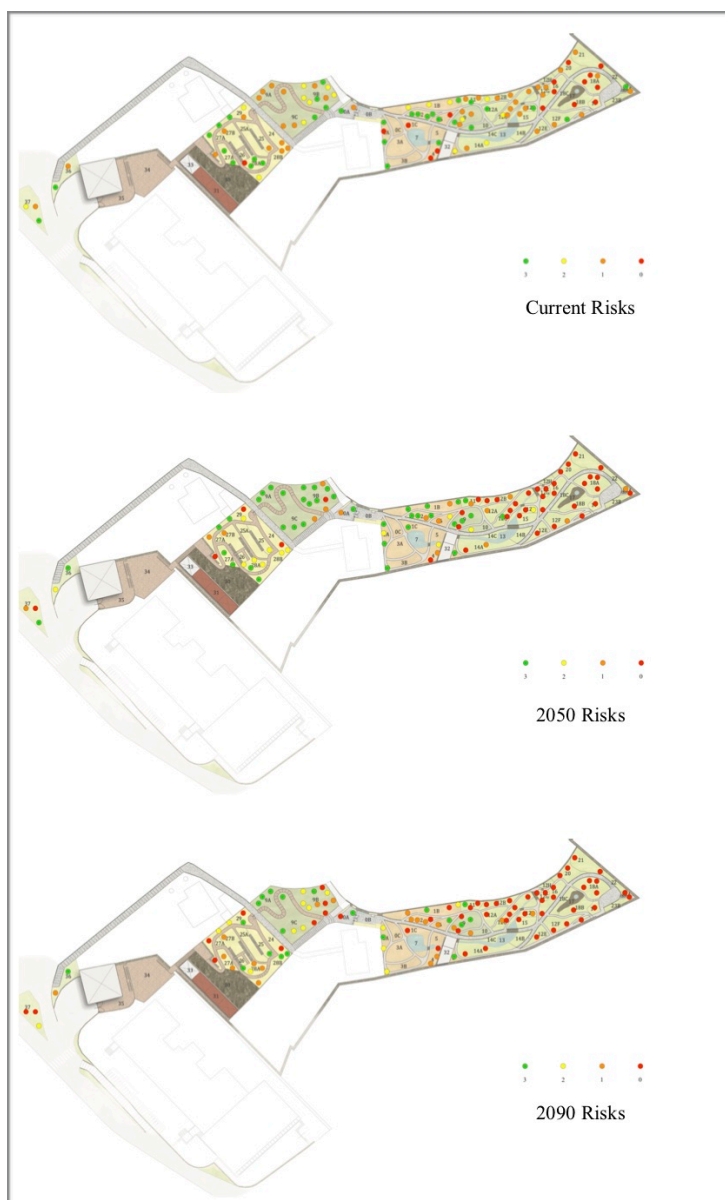
<sup>335</sup> Climate Change Alliance of Botanic Gardens. 2023. Climate Assessment Tool v1. Botanic Gardens Conservation International. Richmond, U.K. Available at <https://cat.bgci.org>. (Accessed on 28/05/2023).

<sup>336</sup> Climate Change Alliance of Botanic Gardens. 2023. Climate Assessment Tool. How to Use the Climate Assessment Tool. Botanic Gardens Conservation International. <https://cat.bgci.org/how-to-use>

The results are clear, the conditions will worsen for most species in both future scenarios, however, in the worst case scenario the majority of species will not be suited anymore to live in their current location. Even with the best care of the institution, 49% of trees will be at the limit of their preferred climatic conditions and 7,5% will be out of it completely (Plant search model). International efforts towards limiting global warming will be the key to reduce the negative impacts on many plant species.

Another interesting data resulting from the chart is that, according to the information gathered by the Global Biodiversity Information Facility (GBIF) on the natural distribution requirements of taxa, the survival rates are much stricter compared to the adaptability of plants that are cultivated in gardens today. The combination of horticultural expertise and plant adaptability can explain the discrepancy between the two models.

In Figure 8, instead, it is possible to better visualize the results thank to the planimetry of the Botanical Garden and the distribution of the taxa examined in this study.



**Figure 8.**

*Visual distribution of the taxa examined of the Botanic Garden of Bergamo “Lorenzo Rota” and the related risk codes of each individual tree under each scenario (current situation, SSP2/RCP4.5 forecast for 2050 and SSP3/RCP7.0 forecast for 2090).*

*The risks are based on the Global Biodiversity Information Facility (GBIF) model which collects data of natural distribution of taxa.*

*The updated planimetry of the Città Alta Section of the Botanical Garden was kindly given to me by the staff of the Botanic Garden, while the mapping of the trees was done in person and subsequently digitalized.*

Among the results it is possible to notice two extremes. First, there are some cases in which taxa will actually improve their conditions, but this is true mostly for exotic species, such as *Citrus trifoliata* (South-east Asian citrus tree), *Trachycarpus fortunei* (palm tree native to South-east Asia), *Zanthoxylum armatum* (Asian shrub used to obtain Sichuan pepper) and *Chamaerops humilis* (a palm tree typical of the Mediterranean area).

On the other hand, most native species will lose their comfort zone soon, like the species *Cornus mas* (European cornel). Moreover, other species native to mountain regions and pre-alpine regions are already struggling, such as *Pinus cembra* (Swiss pine) and *Larix decidua* (European larch), which are mostly found in the right sections of the map.

It is important to notice how several species are not included in the study, especially herbaceous plants, which are the majority of taxa within a garden like the one in Bergamo (due to the limited spaces). It would be very interesting to widen the international digital databases on climate ranges of plants to include not only trees and shrubs, but other forms too. Hopefully, one day there will be multiple international databases that will be of support for better studies in this direction.

In any case, it is undeniable that the Botanic Garden of Bergamo has already been changing its face consistently since its foundation, which did not even happen that long ago, exactly because it was born inspired by alpine and mountainous plants. These plants are the ones experiencing the worst impacts of climate change and for this reason some have already been removed from the collection by the staff of the garden.

The limited dimensions of the botanical garden might be at the advantage of the staff in the future for better control and lesser need of resources for maintaining the collection, although the manpower of the museum is still incredibly little and, if it will not be consolidated, the advantage will be lost. For what concerns the increasing water needs, the director and the curator explained to me how they are already planning on creating a well connected to an underground aquifer (to be completed in 2024), in order to lessen their dependence on public water and ensure a safety measure in case of drought (as it has been in the past two years).

To conclude the chapter, I want to highlight how this analysis is not meant to be a definitive assessment of the collection of the Botanic Garden of Bergamo and its future risks connected to climate change. In fact, a study as such would require much more time dedication, improved botanical knowledge (I speak on my behalf), and more international and national digital information on biodiversity needs and vulnerabilities, as well as more accurate climate forecasts.

Nonetheless, I believe it to be useful to increase the number of studies like this, to give the basis for future strategies and decision making in terms of biodiversity conservation within botanical museums and institutions. And, hopefully, I have contributed in inspiring someone else

to deepen his or her knowledge on the relation between climate and plants in Italy and even outside of it.

## Conclusion

This project is coming to an end. What we have learned so far spans over time and fields and, hopefully, you will see how everything is infinitely connected. The historical premises have contributed to the accumulation of meaning and purposes within gardens and botanic gardens, that are complex assemblages of living entities, both human and non-human.

Botanic gardens can hold political values too and they are constantly trying to adapt their role to preserve their survival, decade after decade. The final frontier of modern times regards sustainability, education and research to face global crises such as climate change and the possible biodiversity 6th mass extinction.

And with the affirmation of the Anthropocene, the society is mainly divided between those that believe that humans must have a role in saving the Earth, undoing their damages, and those that believe that it is arrogant to pursue actions pretending to know what is best for nature, instead of letting Earth find a way to self-regulate its own system, as proposed by the Gaia theory<sup>337</sup>.

The landscape succession strategy might fall into this trap: once again we decide that humans can exert control over nature through models and statistics that give us the confidence over what the future holds for us, even if this does not take into account the complexity and unpredictability of reality. There is a possibility that plants will find their way to adapt to the future climate, probably with consistent losses, yet they have changed in the past and can do it again, simply not in the way we would like it. In some cases, accepting death and *learning to mourn*<sup>338</sup> could be more helpful in understanding reality than to blindly insisting to maintain a stillness where there cannot be.

However, we could read this strategy under an opposite light: as an act of submission to life changes. Humans are starting to accept that things are changing, no matter if we like it or not, and are trying to be part of the change, giving a hand to our fellow plants to facilitate their adaptation.

Could this be the dawn of a new trend for botanic gardens? There was a time in which botanic gardens were competing to find the rarest and most exotic species in the world to expose them as trophies and marvels extracting them out of their context. Will they now reduce their extreme experiments of plant keepers to give more space to more sustainable approaches of conservation? This is too early to tell, and the answer will likely never be univocal.

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<sup>337</sup> J. LOVELOCK. 2003. *Gaia: the living Earth*. *Nature*, 426(6968): 769-770.

<sup>338</sup> T. VAN DOOREN. 2014. *Flight ways: Life and Loss at the Edge of Extinction*. In *Flight Ways*. Columbia University Press.

The diversity of botanic gardens and their micro-systems is special as much as non man-made ecosystems and their way of coping with changes will differ as well. For instance, the application of a landscape succession strategy in Italy seems still far away from becoming real, due to several reasons that can range from lack of funds, resources and in some context lack of initiative and coordination. Yet, the research in this direction is moving and the creation of international guidelines for botanic gardens is incredibly important. Increasing the number of surveys and studies on botanical risks is useful for gaining a panoramic view on the issue, better understanding, and thus useful for more conscious decision making processes as well as for confronting multiple results in different parts of the world, or even the same nation.

In this sense, scientific research should always be promoted, but never considered out of context. Models are useful when analyzed with a critical eye and married with the socio-cultural needs of any place and living assemblage. In fact, even in botanic gardens where techno-scientific adaptation is not a priority, there can be a potential for change. The Botanic Garden of Bergamo has definitely taught me the power of investing in social interaction: there is no need for enormous spaces or the rarest collection of plants, as long as a Botanic Garden can help just one more person to reconnect with natural rhythms and plants, it will be a successful institution.

The predominantly experiential approach to education of the Botanic Garden of Bergamo could be connected to the growing flow of people that contributed to ‘the plant turn’, a turn influenced by the fascination for the plant world that tends to visualize it in a more anthropomorphic way to better communicate and understand it. And I agree with the observations of the anthropologist Natasha Myers with the potential dangers of using typically human terms to describe the plants’ existence, but that it can also be incredibly effective in helping us bond with them more deeply.<sup>339</sup>

Where there is a bond, there can be feelings and fascination. Where there is a *sense of wonder* there can be care.<sup>340</sup> Where there is care there can be *the recognition and enactment of alternative and/or marginalized temporalities*.<sup>341</sup> And where there is self-consciousness over the overlapping phenomena and living processes that compose the Earth, there will be finally harmony: a reunified nature, that is not anymore opposed to the human world.

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<sup>339</sup> N. MYERS. 2015. *Conversations on plant sensing: notes from the field*. Nature Culture, 3: 35-66. p.40

<sup>340</sup> CARSON. 1956. *The Sense of Wonder*.

<sup>341</sup> M. PUIG DE LA BELLACASA. 2015. *Making time for soil: Technoscientific futurity and the pace of care*. Social studies of science, 45(5): 691-716. p.2

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## Annex I - List of the species examined from the Botanic Garden of Bergamo

| Taxon               |  |
|---------------------|--|
| Citrus trifoliata   |  |
| Buxus sempervirens  |  |
| Buxus sempervirens  |  |
| Ilex aquifolium     |  |
| Cornus mas          |  |
| Quercus cerris      |  |
| Malus sylvestris    |  |
| Crataegus monogyna  |  |
| Cornus mas          |  |
| Euonymus europaeus  |  |
| Frangula alnus      |  |
| Prunus spinosa      |  |
| Celtis australis    |  |
| Ilex aquifolium     |  |
| Betula pendula      |  |
| Pinus sylvestris    |  |
| Fraxinus ornus      |  |
| Alnus glutinosa     |  |
| Carpinus betulus    |  |
| Fagus sylvatica     |  |
| Corylus avellana    |  |
| Ostrya carpinifolia |  |
| Betula pendula      |  |
| Taxus baccata       |  |
| Pinus mugo          |  |
| Staphylea colchica  |  |
| Staphylea pinnata   |  |
| Sorbus aucuparia    |  |
| Larix decidua       |  |
| Taxus baccata       |  |
| Picea abies         |  |



| <b>Taxon</b>                 |  |
|------------------------------|--|
| <b>Pinus mugo</b>            |  |
| <b>Alnus incana</b>          |  |
| <b>Pinus cembra</b>          |  |
| <b>Loropetalum chinense</b>  |  |
| <b>Camellia japonica</b>     |  |
| <b>Acer griseum</b>          |  |
| <b>Tetradium daniellii</b>   |  |
| <b>Davidia involucrata</b>   |  |
| <b>Syringa vulgaris</b>      |  |
| <b>Sarcococca hookeriana</b> |  |
| <b>Ilex pernyi</b>           |  |
| <b>Magnolia stellata</b>     |  |
| <b>Juniperus communis</b>    |  |
| <b>Picea abies</b>           |  |
| <b>Pinus mugo</b>            |  |
| <b>Abies alba</b>            |  |
| <b>Laburnum anagyroides</b>  |  |
| <b>Cotinus coggygria</b>     |  |
| <b>Osmanthus fragrans</b>    |  |
| <b>Trachycarpus fortunei</b> |  |
| <b>Punica granatum</b>       |  |
| <b>Magnolia macrophylla</b>  |  |
| <b>Acca sellowiana</b>       |  |
| <b>Prunus lusitanica</b>     |  |
| <b>Pyrus spinosa</b>         |  |
| <b>Trachycarpus fortunei</b> |  |
| <b>Cryptomeria japonica</b>  |  |
| <b>Laurus nobilis</b>        |  |
| <b>Zanthoxylum armatum</b>   |  |
| <b>Corylus avellana</b>      |  |
| <b>Crataegus azarolus</b>    |  |
| <b>Cornus mas</b>            |  |

| <b>Taxon</b>                    |  |
|---------------------------------|--|
| <b>Morus alba</b>               |  |
| <b>Cornus kousa</b>             |  |
| <b>Cornus nuttallii</b>         |  |
| <b>Ziziphus jujuba</b>          |  |
| <b>Chamaecyparis obtusa</b>     |  |
| <b>Chamaecyparis pisifera</b>   |  |
| <b>Chamaecyparis obtusa</b>     |  |
| <b>Chamaecyparis lawsoniana</b> |  |
| <b>Prunus spinosa</b>           |  |
| <b>Morus alba</b>               |  |
| <b>Olea europaea</b>            |  |
| <b>Ulmus minor</b>              |  |
| <b>Paulownia tomentosa</b>      |  |
| <b>Wollemia nobilis</b>         |  |
| <b>Macadamia tetraphylla</b>    |  |
| <b>Sophora microphylla</b>      |  |
| <b>Zanthoxylum americanum</b>   |  |
| <b>Yucca gloriosa</b>           |  |
| <b>Liquidambar styraciflua</b>  |  |
| <b>Chamaerops humilis</b>       |  |
| <b>Olea europaea</b>            |  |
| <b>Ficus carica</b>             |  |
| <b>Vitex agnus-castus</b>       |  |
| <b>Acer monspessulanum</b>      |  |
| <b>Taxus baccata</b>            |  |
| <b>Laurus nobilis</b>           |  |
| <b>Buxus sempervirens</b>       |  |
| <b>Quercus ilex</b>             |  |
| <b>Rhamnus alaternus</b>        |  |
| <b>Quercus coccifera</b>        |  |
| <b>Ficus carica</b>             |  |
| <b>Buxus sempervirens</b>       |  |

| <b>Taxon</b>                |  |
|-----------------------------|--|
| <b>Quercus coccifera</b>    |  |
| <b>Pistacia lentiscus</b>   |  |
| <b>Arbutus unedo</b>        |  |
| <b>Quercus suber</b>        |  |
| <b>Quercus frainetto</b>    |  |
| <b>Olea europaea</b>        |  |
| <b>Chamaerops humilis</b>   |  |
| <b>Juniperus communis</b>   |  |
| <b>Ilex aquifolium</b>      |  |
| <b>Erica arborea</b>        |  |
| <b>Pistacia terebinthus</b> |  |