e-CREHA

Education for Climate Resilient European Heritage Architecture

ERASMUS KA203 - Strategic Partnerships for Higher Education Project

"e-CREHA: **E**ducation for **C**limate **R**esilient **E**uropean **H**eritage **A**rchitecture"

REPORT

O1-Cross-Disciplinary Pedagogies

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This report presents the research results conducted by the project team of Education for Climate Resilient European Heritage Architecture (e-CREHA). The report was prepared by TOBB ETU and peer reviewed by the consortium partners.

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ABBREVIATIONS

ACE	Architects' Council of Europe
CDP	Cross-Disciplinary Pedagogies
e-CREHA	Education for Climate Resilient European Architectural Heritage
EC	European Commission
ECTS	European CreditTransfer and Accumulation System
EEA	European Environment Agency
EU	European Union
HEIs	Higher Education Institutions
GBL	Game-Based Learning
GHG	Greenhouse Gas
GIS	Geographic Information Systems
IPCC	The Intergovernmental Panel on Climate Change
ICCROM	International Center for the Study of the Preservation and Conservation of Cultural History
ICOMOS	International Council on Monuments and Sites
ICT	Information and Communication Technology
INSA	Institut National des Sciences Appliqués Strasbourg
LCP	Local Climate Plan
MOOC	Massive Open Online Courses
NDC	National Determined Contributions
NEBC	The New European Bauhaus Collective
NIKU	Norsk Institutt for Kulturminneforskning
PA	Paris Agreement
SDGs	Sustainable Development Goals
SU	Sofiiski Universitet Sveti Kliment Ohridski
TOBB ETU	TOBB University of Economics and Technology
TU/e	Eindhoven University of Technology
UN	United Nations
UNESCO	The United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIMOL	Università degli Studi del Molise
WHC	UNESCO World Heritage Center

SUMMARY

Climate change affects our health, environment and economy. Over the past years, climate change issues have become increasingly prominent in a variety of fields. This has led to an increased focus on climate change in architectural design and urban planning and accordingly architectural education. The architectural curriculum should place a strong emphasis on the vulnerability of the built heritage to climate change as well as exposing the heritage's role in the development of mitigation and adaptation strategies.

The report titled “Cross-disciplinary Pedagogies” (CDP) is a comprehensive survey and analysis of current interdisciplinary learning/teaching methods and approaches in different categories related to climate change and cultural heritage. The first chapter starts with the problem statement, aim, scope and methodology of the report. The description of the e-CREHA project and the e-course as the output of the project are presented. The content of this report, its purpose, methodology, research and the results of the analysis are introduced afterwards. The second chapter starts by addressing one of the biggest challenges facing our planet, climate change and the vulnerability of the cultural heritage against it. Even though it has negative impacts on local and national communities for their cultural, historical, and socioeconomic values, cultural heritage is also a resource for dealing with this problem and has a key role for a sustainable future. The third chapter includes introduction of the e-CREHA project and the e-learning course with its scope, objectives, and methodology. The fourth chapter includes the presentation of the research/data collection and analysis (qualitative, quantitative, swot) carried out in three separate categories: courses, games, documentaries, and in addition climate governance and the role of plans and policies. The fifth chapter includes concluding remarks by underlying the following matters: education and climate change are becoming more relevant and intertwined. The curriculum which is crucial in current and future undergraduate and graduate education should emphasize how the built heritage is vulnerable to climate change and how pivotal role it plays in developing climate-adaptive strategies. It is obvious that there is a need to bridge the gap between the mechanisms; governance and research & education in order to comprehend multi-level planning mechanisms and deal with potential conflicts between diverse levels of planning frameworks. It is required to improve students' skills and competencies regarding EU actions. The e-CREHA project was designed to address these gaps. This report demonstrates the importance of the e-CREHA, the e-course, and how it may provide fertile ground for the development of innovative architectural curricula for climate-resilient heritage.

Keywords: Climate Change, Cultural Heritage, New Pedagogical Approach, e-Learning Course.

CONTENTS

1. INTRODUCTION

Climate change is one of the greatest challenges facing our planet. If global warming increases at its current rate, the Intergovernmental Panel on Climate Change (IPCC) predicts it will reach 1.5°C between 2030 and 2052. [1] In August 2021, the latest IPCC report was published (AR6 WGI), which warns of extreme heat waves, rising sea levels, droughts, and flooding, and claims the key temperature limit will be exceeded in just over a decade. [2] The evidence is "irrefutable," and the results are so alarming that the Secretary-General of the UN called the report "a red code of humanity." [3]

Cultural heritage in Europe, as well as worldwide, is threatened by human-made disasters and climate change, which impair its integrity and threaten its values.[4] Continual losses of architectural heritage can have a negative impact on local and national communities for their cultural, historical, and socioeconomic values. Heritage contributes to social cohesion, sustainable development, and psychological well being. By mitigating the effects of climate change, we can also make use of the cultural heritage that is impacted and threatened by climate change. The International Council of Monuments and Sites (ICOMOS) points out the gap that is the absence of cultural heritage in the climate discourse.[5] Despite being key institutions for many communities, the culture and heritage sectors are not directly involved in climate change solutions.

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[1] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp* www.ipcc.ch/sr15. Retrieved 2021-11-05.

[2] IPCC, 2021: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press. www.ipcc.ch/report/sixth-assessment-report-working-group-i. Retrieved 2021-11-05.

[3] UN. (2021). Secretary-General's statement on the IPCC Working Group 1 Report on the Physical Science Basis of the Sixth Assessment. https://www.un.org/sg/en/content/secretary-generals-statement-the-ipcc-working-group-1-report-the-physical-science-basis-of-the-sixth-assessment

[4] UNESCO. (2019). Convention Concerning the Protection of the World Cultural and Natural Heritage (Issue July). https://doi.org/10.1007/978-3-319-01384-8_224

[5] ICOMOS. (2019). ICOMOS Work on Climate Change. https://www.icomos.org/en/focus/climate-change/60669-icomos-work-on-climate-change

The role of architecture in reducing climate change effects is crucial. Buildings (both old and new) play a key role in combating climate change, and architects with competencies in sustainable design and resilience are in high demand. Climate change issues have become increasingly prominent in architectural design and planning over the past decade. This has led to an increased focus on climate change in architectural education.

The architectural curriculum should emphasize the vulnerability of the built heritage to climate change as well as the heritage's role in the development of mitigation and adaptation strategies. This gap has also highlighted two critical needs. First, innovative learning methods should be developed to improve the understanding of built heritage values and characteristics. Second, an interdisciplinary approach to education should be adapted to study the complexity of climate change. This approach should overcome the current disparity between research and education. Education must be based on methods that foster high levels of interaction, adaptability to changing environments, and emphasize critical thinking in order to accomplish these objectives. Education can lead to the development of new skills, boosted by the use of ICT-based technologies, as a comprehensive approach to climate change and environmentally friendly professional actions, as well as "ensuring youth employment and smooth transition from training to work." [6]

Education for Climate-Resilient European Heritage Architecture (e-CREHA) aims to train and educate the next generation of tutors, researchers, and professionals that will contribute to the creation of a climate-resilient European cultural heritage. To this end, e-CREHA promotes the social and educational value of European cultural heritage by developing e-learning materials. The outputs of e-CREHA will contribute to better understanding, appreciation, and protection of European architectural heritage values.

e-CREHA proposes an innovative educational method that acknowledges the significance of architectural heritage and its crucial role in the development of climate-adaptive strategies. Therefore, cultural heritage cannot be viewed as a 'patient' incapable of speaking for itself, but rather as a source of knowledge. e-CREHA is dedicated to innovative education and to develop a multi-disciplinary knowledge for building a culture of prevention and mitigation (culture of preparedness) to address climate change. The project's objective is to foster cooperation between research and education in order to enhance our understanding of how cultural heritage and design can contribute to climate change. It highlights that heritage and design have a crucial role in shaping vulnerable environments while preserving them. e-CREHA formulates an innovative e-learning course and methodology focusing on developing climate-resilience for cultural heritage across Europe. It provides an innovative

[6] EU. (2013). Directive 2013/55/EU of the European Parliament and of the Council. Official Journal of the European Union, 132–170. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0132:0170:en:PDF

approach and renewed interpretations of content and methods regarding resilient architectural heritage and climate change in education. The goal of the project is to expand students' intellectual resources and build a new climate-sensitive set of skills. Finally, it enhances students' qualifications in the face of competitiveness in the economy and job creation through societal challenge-based learning. The course will be designed for graduate students in built environment related programs. It will elaborate on three topics: (a)built heritage and the impact of climate change; (b)heritage as a resource for climate change; (c)resilient heritage solutions. The course will include modules, lectures, quizzes/games, video clips, assignments and students' virtual forum/s. The students will receive a certificate of completion stating the specific knowledge they gained.

To conclude, e-CREHA aims to innovate education and create multi-disciplinary knowledge for building a culture of mitigation and prevention, i.e. a culture of preparedness, in order to deal with one of the most challenging issues of our time: climate change. Accordingly, the project promotes a collaborative approach between research and education in order to enhance understanding of ways heritage and design can be used to enhance social awareness of climate change; and it shows how heritage and design can transform vulnerable environments while preserving our heritage.

The report "Cross-disciplinary Pedagogies" (CDP) is the first intellectual output of the e-CREHA project. The CDP is a study to understand the current state of the art on how heritage in architectural education is responding to climate change. In addition to having distinctive qualities (history, memory, topography) that define its cultural heritage, each country has its own climate conditions. These two aspects influence architectural education at each university. This results in a diversity of architectural design courses, models, and methods. Examining how heritage education is responding to climate change through the diversity of schools, each of which has its own research agenda, may provide fertile ground for the development of innovative architectural curricula for climate-resilient heritage. The research involves a survey and an analysis of courses, games, documentaries related to climate resilient heritage and in addition climate governance and the role of plans and policies focusing on partner countries. The partners collected data by searching architecture/built environment schools and related academic institutions within their network.

Data analysis on cross-cultural pedagogies focusing on courses includes a quantitative analysis revealing geographical distribution of the retrieved data, covered topic, multidisciplinary aspects; qualitative analysis which is categorisation and evaluation of courses and design studios according to knowledge, skills and competences (as defined in the directive 55/2013/EU); methods, scope and objectives, issues, skills and competencies, tutors' profiles etc. and a SWOT analysis of each category in order to identify the current limits and the integrative skills necessary to equip future students. The CDP provides the

foundation for the e-CREHA e-learning course, which will inspire other architecture schools in Europe to develop new courses and academic conferences, workshops etc. where knowledge is produced and disseminated related to the recognition and preservation of European heritage.

For the objectives and the aim defined above, e-CREHA brings together the multiple disciplines of architecture and built environment, heritage studies, engineering, climate science, and software technologies and informatics. The e-CREHA consortium strategically allied with all fields related to architectural heritage and climate change. This consortium defined the main aspects and required skills of students on resilience of heritage and design that are lacking in professional practice. The project creates a joint platform of collaboration and cooperation among six partners and a coordinator extending across Europe. Among those participating organizations, Eindhoven University of Technology (TU/e) (coordinator), TOBB University of Economics and Technology (TOBB ETU), Università degli Studi del Molise (UNIMOL), and Institut National des Sciences Appliqués Strasbourg (INSA), Sofiiski Universitet Sveti Kliment Ohridski (SU), Norsk Institutt for Kulturminneforskning (NIKU) and Beeldland. Eindhoven University of Technology (TU/e) is a research university specializing in engineering science & technology. The TU/e-Department of the Built Environment focuses on the Sustainable transformation of the city (Living City program). This program is managed by the unit named as Architecture Urban Design and Engineering (AUDE), one of the four units in the Department of the Built Environment of TU/e and the core unit engaged in spatial, cultural and tectonic aspects of our built environment. TOBB University of Economics and Technology (TOBB ETU) is a private non-profit foundation university founded officially in 2003 by “The Union of Chambers and Commodity Exchanges of Turkey'' (TOBB). It is the first and only university to offer cooperative education in Turkey. Within complex, unpredictable and dynamic theoretical, technological and practical environments of the architectural discipline, the department of architecture was founded with the intention of creating a new curriculum structure, unique in Turkey. The curriculum of the Architecture Department has been structured as a process with the aim to produce new creative knowledge and organize strategies where such knowledge can be applied to resolve real-world problems. Institut National des Sciences Appliqués Strasbourg (INSA) is a State institution of Scientific, Cultural and Professional teaching. The architectural training in the architecture department of INSA Strasbourg is marked by an interdisciplinary approach that conjugates architecture and engineering in a fruitful manner being the place of an obvious collaboration between these disciplines. Taking advantage of this context and its heritage, this training is often the place of experimentation or educational innovations. Università degli Studi del Molise (UNIMOL) contributes to the project by its expertise on developing specific conceptual models for Geographic Information Systems (GIS) applied in civil and environmental engineering, spatial planning with special focus also for applications in tourism planning and governance. The principal aim is to implement a special GIS useful to store, manage and analyze spatial, historical, social, and economic data in order to define

their relations and critical issues. A specially implemented geodatabase is a useful tool to promote tourism in regions and to manage and to protect cultural heritage. Sofia University ‘St. Kliment Ohridski’ (SU) has the largest and most prestigious educational and research center in Bulgaria. The Science-Research Department (SU-NIS) is designed to organize, serve and implement project-based research, oriented towards development of new scientific knowledge and applied research products as well as to contribute to the improvement of the education processes. The Centre of Information Society Technologies (CIST) is an interdisciplinary research and training unit of the Faculty of Mathematics and Informatics, aimed at establishing fruitful cooperation between the University and industry. CIST aims to support national and international governmental, non-governmental and industrial organizations for applying policy documents and strategies related to new technologies. CIST is engaged in training and educational activities supporting the applications of innovative approaches and new technologies in community development, in education, and in corporate training, focusing on the methodological research and dissemination of the best practices related to ICTs. Norsk Institutt for Kulturminneforskning (NIKU) is an independent institute within the wider field of Cultural Heritage in Norway and beyond. It is affiliated with the Ministry of Climate and Environment, focusing on the policies on Climate action and cultural heritage throughout Europe. NIKU’s research addresses issues and problems related to the whole thematic scope of the institute such as history, conservation and adaptation of historic buildings, cultural heritage and climate change, cultural heritage and urban development, heritage management as a means of pursuing wider goals for society. Beeldland is a production company in the Netherlands for producing mainly television documentaries on culture, architecture, history and socially relevant subjects.

2. BACKGROUND:
CLIMATE CHANGE AND CULTURAL HERITAGE

2.1 “A red code for humanity”

The term "climate change" refers to shifts in weather patterns and temperatures over a long period of time. These shifts may be natural, such as through variations in the solar cycle and volcanic eruptions. But since the 1800s, humans have been responsible for climate change, mostly due to burning fossil fuels like coal, oil, and gas. By burning fossil fuels, greenhouse gas (GHG) emissions are created that act as a blanket around the Earth, trapping the sun's heat and causing temperatures to rise. Carbon dioxide and methane are examples of greenhouse gas emissions that cause climate change. These gases are released, for example, from driving a car with gasoline or heating a building with coal. Carbon dioxide, meanwhile, is released from clearing lands and forests. Most methane emissions come from garbage landfills. Therefore, buildings, agriculture, industrial activities, transport, and land use are among the principal emitters. Unfortunately, emissions have continued to increase. This has resulted in Earth's temperature rising by 1.1°C since the late 1800s. [7]

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change in climate caused directly or indirectly by human activity that alters the composition of the global atmosphere.[8] In this definition, natural climate variability and man-induced climate change are two separate phenomena. It's not just about temperature rise. Because the Earth is a system and the changes in one area can affect others. In addition to amplifying existing vulnerabilities and threats, climate change creates new risks. The consequences of climate change can include intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, and catastrophic storms. The sixth IPCC report (AR6 WGI) published in August 2021 announced the urgency of the situation. In 2019, atmospheric CO2 concentrations were higher than in any time in the past 2 million years; Arctic sea ice level was at its lowest level since 1850 and global mean sea level has risen faster than it has in the last 3000 years since 1900. According to the report, extreme weather events are already being caused by climate change. Heatwaves, heavy

[7] UN. (n.d.). What is Climate Change? Retrieved November 5, 2021, from https://www.un.org/en/climatechange/what-is-climate-change#.
[8] UN. (1992). United Nations Framework Convention on Climate Change (Vol. 62220). https://unfccc.int/resource/docs/convkp/conveng.pdf

precipitation, droughts, and tropical cyclones have skyrocketed since 2014.[9] Studies attribute this to human influence. Special Report Global Warming of 1.5°C (2018) by IPCC reports (high confidence) that limiting global warming to 1.5°C will prevent the most severe climate impacts.[10] Yet the current path of CO2 emissions could increase global temperatures by as much as 4.4°C by the end of the century. [11]

The Paris Agreement (PA), signed by 195 countries in 2015 under the auspices of the UNFCCC aims to keep global temperature rise far below 2°C this century, and to intensify efforts to limit it to 1.5°C, compared to pre-industrial levels.[12] PA brought all nations together for the first time to fight climate change and adapt to its impacts. As a result, countries should reduce global GHG emissions as soon as possible to achieve a climate neutral world by mid-century. Countries are required to submit their climate action plans every five years, known as national determined contributions (NDCs). Economic and social transformation are required to implement the PA, based on available science. PA involves a commitment to "building the resilience of socioeconomic and ecological systems, including through economic diversification and sustainable management of natural resources."[13] Countries will take actions to build resilience to adapt to the impacts of rising temperatures.

In 2015, the UN 2030 Agenda introduced 17 Sustainable Development Goals (SDGs). Sustainable Development was reaffirmed by the world community. Through the Agenda, 193 member states committed to promote economic growth, social inclusion, and environmental protection, as well as fostering a just and inclusive society. As the most comprehensive blueprint for eradicating extreme poverty, reducing inequality, and preserving the environment, the Agenda calls for concrete action for people, planet, and prosperity. [14]

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[9] IPCC, 2021: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press. www.ipcc.ch/report/sixth-assessment-report-working-group-i.

[10] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp* www.ipcc.ch/sr15. Retrieved 2021-11-05.

[11] UN. (n.d.). What is Climate Change? Retrieved November 5, 2021, from https://www.un.org/en/climatechange/what-is-climate-change#.

[12] UN. (2015). The Paris Agreement. Article 2 (1a) https://doi.org/10.4324/9789276082569-2

[13] Ibid., Article 7 (9e)

[14] UNSSC. (2015). The 2030 Agenda for Sustainable Development. https://www.unssc.org/sites/unssc.org/files/2030_agenda_for_sustainable_development_kcsd_primer_en.pdfwww.unssc.org

The European Green Deal, launched in December 2019, is a package of policies initiated by the European Commission (EC) to make Europe the first climate-neutral continent by 2050. As a result, the EU sets itself on a fair, cost-effective, and competitive path to achieve its climate targets by 2030. Green Deals play a critical role in EC's implementation of the UN's 2030 Agenda and the SDGs. [15]

2.2 Climate change impacts on cultural heritage

The term cultural heritage includes both the products and the process by which societies acquire tangible and intangible resources from the past. The concept of cultural heritage is not limited to monuments or collections of objects (tangible heritage). The term also refers to traditions or living expressions inherited from our ancestors and passed on to our descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge concerning nature and the universe, or the knowledge and skills required to manufacture traditional crafts (intangible heritage).[16] Cultural heritage assets such as historical buildings, archeological sites, and monuments, as well as their contents and collections are legacy items from our past that lend a sense of place, identity, and aesthetic wellbeing to local communities.[17] Cultural heritage includes not only physical artifacts, but also the knowledge and skills gained through human practices, representations, and experiences related to the objects and spaces recognized by communities as cultural heritage. [18] This project focuses on the built environment and cultural landscapes.

It is imperative to deal with climate change to limit its negative impact on cultural heritage. Impacts defined by IPCC:

> The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial.[19]

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[15] Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper. Europa Nostra, The Hague & Brussels.
[16] UNESCO. (n.d.). What is Intangible Cultural Heritage? Retrieved November 5, 2021, from https://ich.unesco.org/en/what-is-intangible-heritage-00003
[17] Sesana, E, Gagnon, AS, Ciantelli, C, Cassar, JA, Hughes, JJ. Climate change impacts on cultural heritage: A literature review. *WIREs Clim Change*. 2021; 12:e710, p.2. Retrieved from https://doi.org/10.1002/wcc.710.
[18] UNESCO. (2004). Convention Concerning the Protection of the World Cultural and Natural Heritage. https://doi.org/10.5860/choice.41-5055
[19] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press

Heritage assets have always been subjected to interactions with their environment and changed accordingly. Climate change may also affect cultural heritage by affecting the frequency and intensity of hazardous events, such as prolonged droughts, floods, and landslides. In addition, storm surge intensity can lead to erosion, flooding, and possibly marine inundation along coastal areas, and can alter inland fluvial dynamics, endangering cultural heritage. [20] Climate change, precipitation, atmospheric moisture, wind intensity, sea level rise, desertification, and the interactions between climatic changes and air pollution constitute threats to cultural heritage, according to the UNESCO World Heritage Center (2007). [21] Consequently, many direct and indirect effects are likely to occur on the built environment; some decay processes can accelerate while others can be delayed.[22] By interfering with the structure and composition of the affected materials, climate changes can aggravate the physical, chemical, and biological mechanisms that cause deterioration. In historic buildings, drainage infrastructure, structural systems, exterior materials, and interior spaces can be damaged. Table 2.2-1 summarizes impacts of the different climate parameters on cultural heritage.[23] The Noah's Ark (Global Climate Change Impact on Built Heritage and Cultural Landscapes) Project (2004-2007) was funded by the European Union to develop mitigation and adaptation strategies for historic buildings, sites, monuments, and materials that will be most affected by climate change. The project determined the meteorological parameters and changes that were most crucial to the built heritage and cultural landscape; described the effects of climate change on the European monuments over the next hundred years; identified historic buildings, sites, monuments, and materials threatened by climate change and associated disasters; and prepared maps, which depict risk levels of material degradation for different parts of Europe. A vulnerability atlas was produced with the finalized maps. In addition, meteorological information was developed to track damage and potential risks.[24]

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[20] Howard, A. J., Challis, K., Holden, J., Kincey, M., & Passmore, D. G. (2008). The impact of climate change on archaeological resources in Britain: A catchment scale assessment. *Climatic Change*, 91(3–4), 405–422. https://doi.org/10.1007/s10584-008-9426-9; ICOMOS Climate Change and Heritage Working Group. (2019). The future of our pasts: Engaging cultural heritage in climate action. *Outline of Climate Change and Cultural Heritage*. Retrieved from https://indd.adobe.com/view/a9a551e3-3b23-4127-99fd-a7a80d91a29e;Sesana, E, Gagnon, AS, Ciantelli, C, Cassar, JA, Hughes, JJ. Climate change impacts on cultural heritage: A literature review. *WIREs Clim Change*. 2021; 12:e710. https://doi.org/10.1002/wcc.710; UNESCO World Heritage Centre. (2008). *Policy document on the impacts of climate change on world heritage properties. Document WHC-07/16.GA/10 adopted by the 16th general assembly of states parties to the world heritage convention (October 2007)*. Retrieved from http://whc.unesco.org/en/CC-policy-document.

[21] Sesana, E, Gagnon, AS, Ciantelli, C, Cassar, JA, Hughes, JJ. Climate change impacts on cultural heritage: A literature review. *WIREs Clim Change*. 2021; 12:e710, p.2. Retrieved from https://doi.org/10.1002/wcc.710.

[22] Noah's Ark (2011). Global Climate Change Impact on Built Heritage and Cultural Landscapes (Noah'S Ark). https://cordis.europa.eu/project/id/501837/reporting

[23] Sabbioni, C., Cassar, M.lEFEVRE, R.A. "Vulnerability of Cultural Heritage to Climate Change," European and Mediterranean Major Hazards Agreement (EUR-OPA), 2008. www.coe.int/t/dg4/majorhazards/activites/2009/Ravello15-16may09/Ravello_APCAT2008_44_Sabbioni-Jan09_EN.pdf

[24] Noah's Ark (2011). Global Climate Change Impact on Built Heritage and Cultural Landscapes (Noah'S Ark). https://cordis.europa.eu/project/id/501837/reporting

Vulnerability is “the potential or likelihood to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt”.[25] A vulnerability assessment of heritage involves methodology such as the climate vulnerability index developed by ICOMOS that considers how climate change might impact the values associated with heritage properties and sites. In order to address the challenges climate change presents to conservation and management of cultural heritage, a vulnerability assessment is needed so that heritage managers can identify the climate change impacts and assess and integrate them into conservation frameworks and management plans.

Climate parameters	**Climate change risk**	**Physical, social and cultural impacts on cultural heritage**
Atmospheric Moisture Change	● Flooding (sea, river) ● Intense rainfall ● Changes in water table levels ● Changes in soil chemistry ● Groundwater changes ● Changes in humidity cycles ● Increase in time of wetness ● Sea salt chlorides	● pH changes to buried archaeological evidence ● Loss of stratigraphic integrity due to cracking and heaving from changes in sediment moisture. Data loss preserved in waterlogged / anaerobic / anoxic conditions ● Eutrophication accelerating microbial decomposition of organics ● Physical changes to porous building materials and finishes due to rising damp ● Damage due to faulty or inadequate water disposal systems; historic rainwater goods not capable of handling heavy rain and often difficult to access, maintain, and adjust ● Crystallization and dissolution of salts caused by wetting and drying affecting standing structures, archaeology, wall paintings, frescoes, and other decorated surfaces ● Erosion of inorganic and organic materials due to flood waters biological attack of organic materials by insects, moulds, fungi, invasive species such as termites ● Subsoil instability, ground heave and subsidence ● Relative humidity cycles/shock causing splitting, cracking, flaking, and dusting of materials and surfaces ● Corrosion of metals ● Other combined effects e.g., increase in moisture combined with fertilizers and pesticides

[25] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press

Temperature Change	• Diurnal, seasonal, extreme events (heat waves, snow loading) • Changes in freeze-thaw and ice storms, and increase in wet frost	• Coastal erosion/loss • Intermittent introduction of large masses of 'strange' water to the site, which may disturb the metastable equilibrium between artifacts and soil • Permanent submersion of low-lying areas • Population migration • Disruption of communities • Loss of rituals and breakdown of social interactions
Sea Level Rises	• Coastal flooding • Sea water incursion	• Coastal erosion/loss • Intermittent introduction of large masses of 'strange' water to the site, which may disturb the metastable equilibrium between artifacts and soil • Permanent submersion of low-lying areas • Population migration • Disruption of communities • Loss of rituals and breakdown of social interactions
Wind	• Wind-driven rain • Wind-transported salt • Wind-driven sand • Winds, gusts and changes in direction	• Penetrative moisture into porous cultural heritage materials • Static and dynamic loading of historic or archaeological structures • Structural damage and collapse • Deterioration of surfaces due to erosion
Desertifi-cation	• Drought • Heat waves • Fall in water table	• Erosion • Salt weathering • Impact on health of population • Abandonment and collapse • Loss of cultural memory
Climate and Pollution Acting Together	• pH precipitation • Changes in deposition of pollutants	• Stone recession by dissolution of carbonates • Blackening of materials • Corrosion of metals • Influence of bio-colonization
Climate and Biological Effects	• Proliferation of invasive species • Spread of existing and new species of insects (eg. termites) • Increase in mould growth • Changes in lichen colonies on buildings • Decline of original plant materials	• Collapse of structural timber and timber finishes • Reduction in availability of native species for repair and maintenance of buildings • Changes in the natural heritage values of cultural heritage sites • Changes in appearance of landscapes • Transformation of communities • Changes in the livelihood of traditional settlements • Changes in family structures as sources of livelihoods become more dispersed and distant

Table [2.2-1] Impacts of the different climate parameters on cultural heritage
Source: Sabbioni, C., M. Cassar, R.A. Lefevre, 2008.[26]

[26] Sabbioni, C., Cassar, M., Brimblecombe, P., & Lefevre, R. A. (2008). Vulnerability of Cultural Heritage to Climate Change. https://www.coe.int/t/dg4/majorhazards/activites/2009/Ravello15-16may09/Ravello_APCAT2008_44_Sabbioni-Jan09_EN.pdf

2.3 Responding to climate change

A response to climate change involves adjusting to risk either in response to or in anticipation of a changing climate. Risk defines a potential for adverse impact on something of value, and the outcome cannot be predicted. Risks have two components: their chance of happening and their impact. Risk relates to the future; something that may occur that would negatively affect our goals. In the context of the assessment of climate *impacts*, IPCC defines the term risk:

> The potential for adverse consequences of a climate-related *hazard*, or of *adaptation* or *mitigation* responses to such a hazard, on lives, *livelihoods*, health and *well-being*, *ecosystems* and species, economic, social, and cultural assets, services (including *ecosystem services*), and infrastructure. Risk results from the interaction of *vulnerability* (of the affected system), its *exposure* over time (to the hazard), as well as the (climate-related) hazard and the *likelihood* of its occurrence.[27]

Heritage collections, buildings, monuments, sites, and our objectives concerning their use ICT and preservation may be negatively affected by a wide variety of factors. Risk is expressed in this case by the expected loss in value of the heritage asset. Risks can be sudden traumatic events such as an earthquake, flood, fire, or armed conflict or gradual and cumulative processes such as chemical, physical, or biological degradation. In both cases the result is loss of value to the heritage asset.[28]

Physical effects such as freezing and thawing, thermal shock, or changes in humidity are closely related to changes in environmental parameters. The result can be exfoliation, powdering, detachment, or worsening of cracks and deformation, resulting in decay and loss of cultural value. Furthermore, cultural heritage will be vulnerable to unknown multi-risk situations, posing new challenges to its protection.[29]

The concept of risk management encompasses everything we do to understand and address potential negative impacts on our objectives. Risk management includes identifying, analyzing, and prioritizing risks. To reduce the risks that we consider unacceptably high, we take actions to "control" them, i.e., to avoid, eliminate, or reduce them.[30] The risk

[27] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press

[28] ICCROM. (2016). A Guide to Risk Management of Cultural Heritage. https://www.iccrom.org/wp-content/uploads/Guide-to-Risk-Managment_English.pdf

[29] Sesana, Elena & Gagnon, Alexandre & Bonazza, Alessandra & Hughes, John. (2019). An integrated approach for assessing the vulnerability of World Heritage Sites to climate change impacts. Journal of Cultural Heritage. 41. 10.1016/j.culher.2019.06.013.

[30] ICCROM. (2016). A Guide to Risk Management of Cultural Heritage. https://www.iccrom.org/wp-content/uploads/Guide-to-Risk-Managment_English.pdf

management process requires the steps of risk management preparation, risk assessment, adaptation planning, and adaptation action, and the evaluation of adaptation progress. Risk management preparations begin with defining the historic place to be investigated and describing its cultural significance. Risk assessment includes establishing hazards and impacts and relationship to climate change as well as analyzing and rating risks to consider their effects on cultural significance. Risk assessment refers to the quantitative and qualitative evaluation of a risk. Adaptation planning is the process of identifying adaptation measures and developing adaptation strategies; adaptation action includes designing and implementing adaptation measures.[31] Since the impact of a disaster will be influenced by the decisions made in the past, it is also necessary to incorporate pre-disaster circumstances, mitigation practices, and preparedness for comprehensive risk management.

There is no doubt that the loss of architectural heritage over a period results in a serious impact on the cultural, historical, and social values of communities. It is our responsibility to preserve and transmit our collective cultural heritage to future generations. Cultural heritage has the potential to help in resiliency and mitigation efforts.

2.4 What is resilience?

The term resilience refers to the processes of cultural heritage protection, preparation, and recovery. Two notions of resilience, engineering resilience and ecological resilience apply to different processes. Engineering resilience describes the ability of an ecosystem to regain equilibrium after a disaster. Ecological resilience, on the other hand, refers to the ability to withstand shocks. The terms express two contrasting aspects of stability. The goal of engineering resilience is to maintain the efficiency of systems. However, environmental resilience is about ensuring that the systems continue to function. Engineering resilience emphasizes the notion of bouncing back to a previous state, whereas ecological resilience emphasizes the notion of bouncing forward to a new state. [32]

Evolutionary resilience is a more recent notion of resilience. The term refers to the return to a previous equilibrium or increased capacity for coping with disturbances. Evolutionary resilience is a new form of a system that is more able to cope with shocks and stresses relating to preparedness. It involves absorption, learning, adaptation, and transformation. Moreover, it highlighted the link between social and ecological systems and helped to

[31] Adapt Northern Heritage (2017-2020). (2020). Adaptation stories: Examples of risk assessment, adaptation planning and conservation management of northern historic places, 8. https://niku.brage.unit.no/niku-xmlui/bitstream/handle/11250/2736543/AdaptNorthernHeritage_AdaptationStories.pdf?sequence=2&isAllowed=y

[32] Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2):5. http://dx.doi.org/10.5751/es-00650-090205;
Qian Wang, Maskazu Yamashita, "Social-Ecological Evolutionary Resilience: A proposal to Enhance "Sustainability Transformation" about Theoretical Foundation", Open Access Library Journal Vol.02 No.03(2015), Article ID:6814110.4236/oalib.1101426.

transform the concept into one that was more compatible with the current uncertainties.[33] In the context of climate change, the concept of cultural resilience is the capacity of a cultural system to absorb adversity, deal with change and contribute to cultural resilience. Cultural resilience includes both continuity and change; crises are not an enemy to be avoided but a catalyst for attaining cultural sustainability.[34] A system's resilience is its ability to absorb disturbances and reorganize while undergoing change so that it maintains its essentially same function, structure, and feedback, and therefore its identity. In other words, resilience is a concept that refers to the ability to adapt to change in order to retain identity.[35]

IPCC (2012) gave definition of resilience:

> The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.[36]

The model of the adaptive cycle is a tool for understanding resilience which was derived from the comparative study of the dynamics of ecosystems [Figure 2.4-1]. It emphasizes processes of destruction and reorganization, which are often overlooked in favor of growth and conservation. The inclusion of these processes enhances the understanding of system dynamics, linking system organization, resilience, and dynamics.[37] Adaptive cycle describes the progression of a social ecological system as it progresses through various phases related to the shock. Adaptive cycle consists of four phases. The growth of exploitation (r), the conservation (K), the collapse or release (Ω), and the reorganization (α). During the exploitation phase of a system's cycle, the system engages in rapid growth. Then, there is an incremental transition to the second phase, merging into a conservation phase (K). This process comprises a slow, continuous forward loop of the cycle, which is reasonably predictable in terms of a system's dynamics. During phase K, the system becomes

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[33] Qian Wang, Maskazu Yamashita, "Social-Ecological Evolutionary Resilience: A proposal to Enhance "Sustainability Transformation" about Theoretical Foundation", Open Access Library Journal Vol.02 No.03(2015), Article ID:6814110.4236/oalib.1101426; Elizabeth Brooks, Abid Mehmood, Simin Davoudi,"Evolutionary Resilience and Strategies for Climate Adaptation," Planning, Practice & Research, 2013 Vol. 28, No. 3, 307–322, http://dx.doi.org/10.1080/02697459.2013.787695.

[34] Thiele, L. P. 2016. Sustainability. 2nd ed. Cambridge: Polity, 36.

[35] Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2):5. http://dx.doi.org/10.5751/es-00650-090205; Folke, C., S. R. Carpenter, B. H. Walker, M. Scheffer, F. S. Chapin III, and J. Rockström. 2010. Resilience thinking: integrating resilience, adaptability and transformability. Ecology and Society 15(4):20. http://www.ecologyandsociety.org/vol15/ iss4/art20/

[36] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press

[37] Resilience Alliance. (n.d.). Adaptive Cycle. Retrieved November 6, 2021, from https://www.resalliance.org/adaptive-cycle

increasingly constrained and less responsive to external shocks as resources are locked up. Inevitably, it is followed by a chaotic phase of collapse and release (Ω) followed by a phase of reorganization (α), either rapid or slow, and during which new opportunities can be developed. The Ω and α phases together constitute an unpredictable back loop. The α phase precedes the r phase, which may be similar to the previous r phase or may differ considerably.[38] From r to K, the fore loop represents growth and accumulation. The back loop from Ω to α is the rapid reorganization phase leading to renewal.

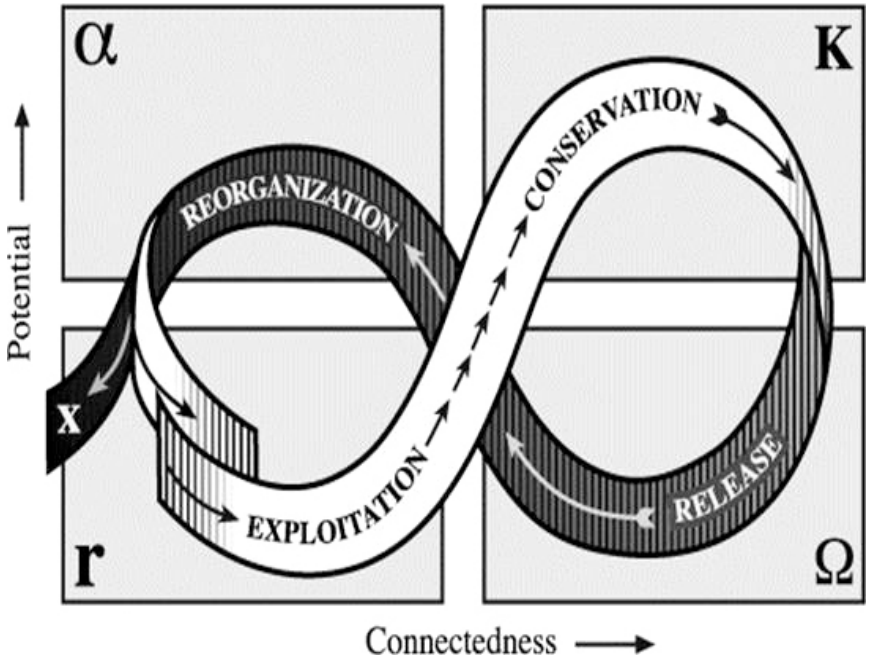

Figure 2.4-1 The Adaptive Cycle
Source: Resilience Alliance - Adaptive Cycle (resalliance.org)

By focusing solely on a single scale, no system can be understood or managed. All systems exist at various scales of space, time, and social organization. In any particular focal scale, interactions across scales play a critical role in determining the dynamics of the system. Panarchy refers to nested hierarchies of adaptive cycles. Phases of the adaptive cycle at one level can be connected with phases at another level in multiple ways [Figure 2.4-2]. Panarchy explains the complex interaction between change and permanence, between the predictable and the unpredictable; pan-archies are structures that support experiments, test the results, and allow for adaptive evolution.[39] Multiple connections may exist between phases of the adaptive cycle at one level and phases at another level. There are two important connections: "revolt" and "remember." At the smaller, nested levels, discoveries are made, experiments and tests are made, while at the larger, slower levels, the system is

[38] Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2):5. http://dx.doi.org/10.5751/es-00650-090205;
[39] Lance H. Gunderson and C.S. Holling 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press.

stabilized, and its accumulated memories are conserved. The slower and larger levels, in this way, create the conditions within which the smaller and faster ones can operate. The approach represents an alternative model for managing issues that arise from the interaction between systems of people and nature. That interaction produces countless surprises, sometimes the result of slow changes that cumulatively shift an ecosystem or an economy into a qualitatively different state. The state might be both impoverished and irreversible. To achieve a sustainable society, it is vital to understand how such changes occur. [40]

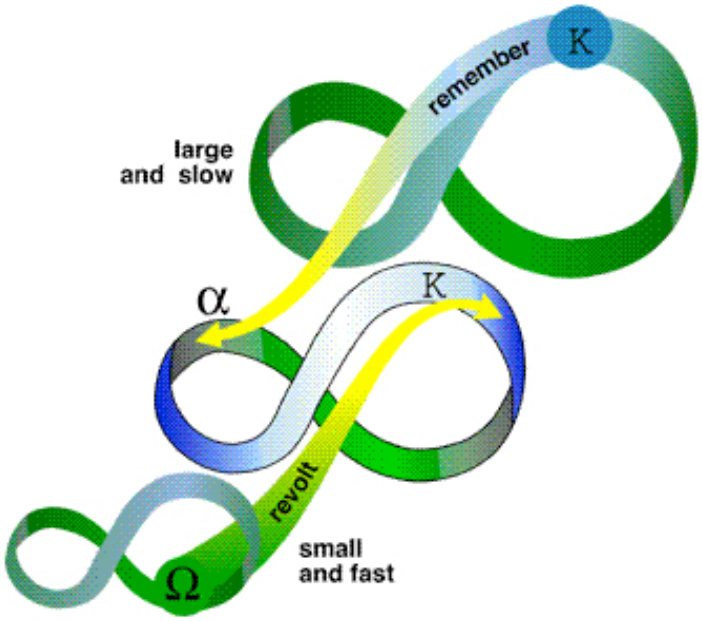

Figure 2.4-2 Panarchy Connections
Source: Resilience Alliance - Adaptive Cycle (resalliance.org)

In the framework of resilience thinking, the concept of adaptability refers to the ability of actors in a system to learn from experience and knowledge, innovate, and adapt their responses and institutions to changing external factors and internal processes. Resilience involves both continuity and change. In short, resilience is the capacity to understand and deal with change. Knowing how and why a system is changing and what the forces are influencing the change help us to build the capacity to deal with change and not become a victim of it.

[40] Lance H. Gunderson and C.S. Holling 2002. Panarchy: Understanding Transformations in Human and Natural Systems.

2.5 Cultural heritage can help: The role of cultural heritage for a sustainable future

> Just as there is no 'Planet B,' there is no 'Venice B.' Now is the time to leverage the formidable connecting force of Europe's cultural heritage to win hearts and minds in support of transformative climate action.
>
> European Cultural Heritage Greenpaper, 2021

The urgent need for decreasing global net anthropogenic emissions of carbon dioxide (CO_2) fostered a global call for sustainable development. The year 2015 witnessed the adoption of the PA and the UN 2030 Agenda for Sustainable Development that set 17 SDGs. These goals include achieving sustainable consumption and production, managing natural resources sustainably, and fighting climate change urgently. [41] Along with the PA, the SDGs emphasized the need for fundamental changes in our lifestyles, industries, and consumption patterns. To achieve the SDGs, the EU developed the Green Deal to reduce GHGs in a decade. In order to meet the goals of the Green Deal, extensive, innovative, and immediate energy transitions should be implemented. Furthermore, climate action cannot be restricted to innovative technologies alone, rather, it must also take into account communal and collective factors. Europe as a whole must work together to achieve zero net GHG emissions by 2050. Culture influences how people respond to climate change actions. To bring about transformative change, it is imperative that it is extended to all segments of society by addressing cultural heritage. Europe's shared values and heritage are undeniably key to the success of the European Green Deal. The value of cultural heritage extends beyond its physical presence. People connect with places through their cultural heritage. It is a part of people's identities and inherent in almost every aspect of their life. As a result, it fosters a sense of belonging, promotes social inclusion, and brings individuals together to collaborate more effectively. Cultural heritage can thus be used to raise awareness about climate change and the need for climate action. Culture may be impacted profoundly by climate change. However, it can also be a source of creativity, innovation, and knowledge that can inspire and guide transitions to low carbon, climate resilient futures. [42]

A dual approach to climate change is promoted by ICOMOS, which seeks both to address the risks climate change poses to cultural heritage as well as to promote heritage as a source of resilience and a resource for climate action.[43] The Future of Our Pasts: Engaging Cultural Heritage in Climate Action (2019) and European Cultural Heritage Greenpaper: Putting Europe's Heritage at the Heart of the European Green Deal (2021) all assert that

[41] UN. (2015). Transforming Our World: the 2030 Agenda for Sustainable Development. https://doi.org/10.1163/157180910X12665776638740

[42] Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper.Europa Nostra, The Hague & Brussels, 6.

[43] ICOMOS. (2019). ICOMOS Work on Climate Change. https://www.icomos.org/en/focus/climate-change/60669-icomos-work-on-climate-change

cultural heritage is not only a vulnerable asset, but also renewable and adaptable.[44] The EU Cultural Heritage Greenpaper attaches significant importance to cultural heritage. Heritage assets should be identified and conserved for their historical, aesthetic, social, and economic values. A value-based reuse and retrofit of heritage may be an excellent adaptation and mitigation strategy for climate resilient development.[45]

The IPCC defines mitigation as "a human intervention to reduce carbon emissions or enhance the sinks of greenhouse gases" in order to limit the temperature rise to 1.5 degrees celsius as agreed in the PA.[46] Green energy technologies, retrofitting and reuse of existing building stocks, sustainable public transport, are all part of it. Some of the mitigation measures adopted nature based solutions such as planting trees and grass along steep slopes to stabilize the earth and prevent landslides or to provide a natural barrier against highways.

Cultural heritage offers possibilities and space for bringing nature into cities and enhancing biodiversity. Most historic districts are dense, walkable, mixed-use areas that promote public transportation, walking, cycling, and make driving less of a necessity. In these areas, there are generally more trees and less asphalt, which helps to keep inner-city spaces cool. Preserving these characteristics in historic neighborhoods and integrating them into land use planning and peripheral urban development is a powerful GHG emissions mitigation strategy.[47]

In order to reach the net-zero target, the European Green Deal emphasizes renovation as a key element. By looking from a circular economy perspective, the built heritage is a great resource that is adaptable and receptive to transformation. The built heritage can contribute to reducing our ecological footprint and the costs associated with demolition and construction. The carbon footprint of buildings includes both operating emissions (from the use of buildings) and embodied emissions (from their construction processes).[48] In the medium-term and at a low cost, built heritage offers powerful solutions to climate change

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[44] ICOMOS Climate Change and Heritage Working Group. (2019). The future of our pasts: Engaging cultural heritage in climate action. *Outline of Climate Change and Cultural Heritage*. Retrieved from https://indd.adobe.com/view/a9a551e3-3b23-4127-99fd-a7a80d91a29e; Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper .Europa Nostra, The Hague & Brussels.

[45] Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper.Europa Nostra, The Hague & Brussels, 31-32.

[46] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press

[47] Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper. Europa Nostra, The Hague & Brussels.

[48] United Nations Environment Programme (2021). 2021 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi. 2021 Buildings-GSR - Executive Summary ENG.pdf (globalabc.org)

challenges. There is a need to place greater emphasis on evaluation of buildings over their lifetime, so that sustainable architectural solutions can be considered superior to solutions that appear more effective or cost-effective in the short term.[49] Rehabilitating abandoned historic buildings and sites can be an effective alternative to demolition in order to avoid wasteful processes and extend the life of the built heritage. Adapting and reusing built heritage reduces raw material and energy consumption, eliminates waste, reduces environmental costs, and GHG emissions. [50]

The adaptation and reuse of existing buildings, as well as built heritage, plays a significant role in adapting to climate change.[51] Especially when cultural values are incorporated into the adaptation governance process, heritage can support adaptation. Climate change adaptation are the adjustments in natural or human systems in response to climate change effects. The PA identifies the adaptation action that "should be based on and guided by the best available science and as appropriate traditional knowledge, knowledge of indigenous peoples and local knowledge systems."[52] Even though contemporary methods are effective for identifying and quantifying the problems, the vast amount of historical knowledge and experience that have grown over time and are available to us through cultural heritage, are also valuable assets for developing appropriate solutions. Through time, communities have developed tools and strategies to respond to local conditions and landscape changes, including architectural adaptations and settlement patterns. The use of traditional building methods and land management practices in cultural landscapes can contribute to resilience to climate change impacts. [53] Traditional skills and knowledge can improve the prevention of a disaster. One of the best examples of this is the polder system in the Dutch deltas. In the Netherlands, traditional polders have been formed since the 12th century, when people began cultivating land by redirecting delta swamps into nearby rivers. Flooding has always been a risk in the polders, so dykes have been built.

Even though climate action has many cultural aspects, "art", "culture", "heritage", and "landscape" are not adequately emphasized in the European Green Deal. [54] In September 2020, the European Commission launched its New European Bauhaus Initiative to provide

[49] ACE. (2018). 20 Architectural Projects Against Climate Change.
[50] Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper. Europa Nostra, The Hague & Brussels.
[51] IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.
[52] UN. (2015). The Paris Agreement.Article 7 (5) https://doi.org/10.4324/9789276082569-2
[53] Potts, A (Lead Author). 2021. European Cultural Heritage Green Paper.Europa Nostra, The Hague & Brussels, 24-30.
[54] Ibid. p.6

"a bridge between science and technology and art and culture."[55] The New European Bauhaus Collective (NEBC) aims to provide a link between the European Green Deal and culture. NEBC adds a cultural dimension to the economic, social, and environmental measures of the European Commission's Renovation Wave strategy.[56] The Commission initiates a paradigm shift by introducing quality architecture and design as key principles in the Renovation Wave. This can be a game-changer in the transition to a more sustainable economy and society.[57] The New European Bauhaus projects combine sustainable design with art and culture; energy efficiency, demographics, and the use of natural materials are considered while they are adapted to the local context. Thousands of organizations and EU citizens participated in the co-design phase from January to June 2021, sharing their views and experiences. As a result, four themes emerged: "reconnecting with nature", "regaining a sense of belonging", "prioritizing places and people who need it most", and "fostering long-term life cycle thinking in the industrial ecosystem."[58] Historic buildings meet all four themes. Historical buildings have a low environmental impact. They are mostly connected to nature and provide a sense of belonging. Also, we can learn from past knowledge of local resources and vernacular traditions, such as passive heating and cooling, traditional building techniques, and land management in cultural landscapes. This knowledge can be adapted to current mitigation strategies and integrated into innovative solutions.

e-CREHA examines three aspects of heritage: traditional construction techniques, cultural meanings and implications, and innovative technological approaches in adaptation. It elaborates on the relationship between heritage and climate change accordingly. e-CREHA activities focus on three specific themes:

a. Knowledge: RESILIENCE (conceptualization/prospective)
b. Resource: IMPACT (contextualization) and VULNERABILITY (uncertainty/exposure)
c. Solution: ADAPTATION (Innovation/creativity/originality)

The PA established the global goal of enhancing mitigation efforts and adaptive capacity, strengthening resilience, and reducing vulnerability to climate change.[59] It acknowledges the parties that adaptation action should be "based on and guided by the best available science and, as appropriate, traditional knowledge."[60] In this regard, cultural heritage is a crucial asset for achieving UN Sustainable Development Goals, in particular SDG13 on Climate Action.[61] Cultural heritage can boost the ambition and capacity of communities to act, support climate adaptation and resilience, contribute to mitigation interventions to

[55] European Commission, "Press statement by President von der Leyen on the New European Bauhaus," Brussels, 14 October 2020. https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_20_1902.
[56] Ibid.
[57] NEBC, "Statement:Making the Renovation Wave a Cultural Project", 2020. NEBC statement.docx (ace-cae.eu)
[58] EU. (2021). New European Bauhaus. https://europa.eu/new-european-bauhaus/delivery_en
[59] UN. (2015). The Paris Agreement. https://doi.org/10.4324/9789276082569-2, Article 4(2); 7(1);10(2)
[60] Ibid., Article 7(5).
[61] UN. (n.d.). Sustainable Development Goals: Goal 13: Take urgent action to combat climate change and its impacts. Retrieved November 5, 2021, from https://www.un.org/sustainabledevelopment/climate-change/

reduce GHG emissions, and address loss and damage from climate impacts, lead for identifying risk and finding and implementing appropriate solutions, and building community resilience and social cohesion.[62]

[62] Europa Nostra. (2020). Cultural Heritage as an integral dimension of the " New European Bauhaus " initiative. supra note 39. https://www.europanostra.org/wp-content/uploads/2020/12/202012-New-European-Bauhaus_Europa-Nostra-Statement.pdf

3. CLIMATE CHANGE AND HERITAGE EDUCATION

3.1 Mind the gap

Reaching the PA goals, the transition to zero emission, energy-efficient and resilient buildings and construction is imperative because the construction sector is a major emitter. The role of architecture in reducing climate change effects is crucial. Buildings (old and new) play a critical role in mitigating climate change. Over the past decade, climate change issues have become increasingly relevant to architectural design and planning. The Architects' Council of Europe (ACE) has urged architects to become more prominent in climate adaptation. The ACE promotes a holistic approach to the built environment, which focuses on achieving economic, social, environmental, and cultural value for all. The goal of renovation strategies should be to optimize the energy performance of buildings while protecting and enhancing the built environment at the same time.[63] In order to mobilize climate action and to develop and implement mitigation as a strategy, we should give special attention to our built heritage. Future architects should be aware of their role in the climate crisis and develop new skills to design resilient and sustainable structures. However, architectural and urban planning education has largely ignored the vulnerability of built heritage to climate change and the role that heritage can play in climate-adaptive strategy development.

In most countries, the culture and heritage sectors are not directly involved in tackling climate change. International organizations like UNESCO, ICOMOS, and EC have emphasized the absence of cultural heritage in climate discourse. They publish plans & policies promoting monitoring, mitigating, and adapting to climate change. The development of effective strategies at the policy level, such as adaptation and mitigation strategies, is essential for managing cultural heritage at risk. While climate change effects are well known worldwide, research and quantification of their impacts on cultural heritage are still limited. In this regard, climate change cannot be included in conservation procedures and management practices at all levels, from government policies to field practice. Implementation of plans and policies at local scales requires awareness of climate change action, skilled human resources and capacity building. Participation of communities, involvement of people on the front line, and integration of nature and culture are becoming increasingly imperative for mitigation of climate change. For developing and applying

[63] ACE. (2021). A Sustainable, Fair and Beautiful Built Environment to Address the Climate and Biodiversity Crisis. October. https://www.ace-cae.eu/fileadmin/user_upload/ACE_CC_CONF_DRAFT_STATEMENT.pdf

mitigation and adaptation measures specialized professionals having a solid base of knowledge and skills are needed. It is also critical to apply, update, and develop professionals' skills continuously. Knowledge, expertise and experience from different fields and disciplines must be integrated to address climate change and embrace heritage as a resource and driver for sustainable development.

As a result, education and climate change are becoming more relevant and intertwined. Social cohesion, sustainable development, and psychological well-being are enhanced by heritage. Protecting heritage therefore promotes resilience. Thus, environmental education must be an integral part of architecture education to be used at both academic and professional levels. It is essential to educate the next generation of tutors, researchers and cultural heritage professionals in order to build a climate-resilient cultural heritage.

In UNESCO/UIA Charter for Architectural Education Revised Edition (2011), approved by International Union of Architects General Assembly, Tokyo, it is stated that architectural heritage education is essential to "understanding sustainability, the social context and sense of place in building design", and "transforming the professional architectural mentality so that its creative methods are part of a continuous and harmonious cultural process."[64]

In this context, the curriculum should emphasize how the built heritage is vulnerable to climate change and how pivotal role it plays in developing climate-adaptive strategies. The courses that address these topics should be based on the latest research. There is a need to bridge the gap between research and education in order to deal with climate change. Research-based knowledge should be applied to education. For years, protecting and conserving built heritage has been regarded as a professional skill, acquired only by architects, planners, and heritage specialists. In the past decade, however, there has been an effort to broaden the heritage field. Formerly, confined to conservation and monitoring, the approach has evolved to integrate expertise, knowledge and experience from various fields to manage change. It also recognizes heritage as a catalyst for sustainable development.

The relation between climate change and cultural heritage is a complex issue that has many dimensions (science, economics, society, politics and moral and ethical). Therefore, courses should be designed using an interdisciplinary approach. It is essential to innovate learning methods so that cultural heritage values can be better understood. Theoretical knowledge and practice should be blended. Schools should use methods that foster high levels of interaction, adaptability to changing environments. A comprehensive approach to

[64] Refer to Appendix X, UIA paper on Heritage Education, of UIA Education Commission Reflection Group 7, on Heritage Education, Torino 2008. UNESCO/UIA CHARTER FOR ARCHITECTURAL EDUCATION Revised Edition 2011 Approved by UIA General Assembly, Tokyo 2011. General Consideration, article 10.

climate-sensitive and environmentally friendly professional actions can be accomplished through education, enhanced by the use of ICT-based methods.

The e-CREHA project addresses the gaps outlined above. This project is a bottom up research. It aims to constitute the knowledge between education and research as recommended by the 2018 EU modernization agenda. The project explores how research, education, and architectural design interact with professional practice. Multi-disciplinary experts and students from different European higher education institutes will work together throughout the project to boost the activities.

Despite the needs outlined above, it is unknown how and to what extent heritage education relates to climate change and/or how heritage education can respond to climate change. CDP research addresses this gap. We collected data on cultural heritage and climate-related courses, games, documentaries and climate governance and the role of plans and policies in the e-CREHA Consortium. In addition to having distinctive qualities (history, memory, culture) that define built heritage characteristics and values, each country has its own climate conditions. Findings are reported in the following chapters.

3.2. e-CREHA e-learning course

3.2.1 The Course Description and Subjects

An e-learning course developed by e-CREHA incorporates heritage-related disciplines and is applied to practice and research fields of the built environment. In recent years, e-learning courses to combine learning strategies/methods with technology have become widespread. They have focused on the vast possibilities for content dissemination and connection. To overcome limitations of time and distance, e-CREHA has developed an online learning course.

Modules of the course will include lectures, videos, quizzes and games, interviews with experts, assignments, and a virtual forum for students. It will also include on-site fieldwork. It will raise students' awareness of heritage's contribution to climate change and serve to acquire relevant knowledge and a comprehensive set of skills for the development of a climate-resilient European heritage. Designed for students in the Built Environment, the e-CREHA course will be added as an elective course with 5 credits to the curricula of the partner HEIs. The course will include eight modules in four sections that cover a different aspect of climate resilience each semester:

a. RESILIENCE: Built heritage and resilient concepts
    Module 1: Resilience, heritage, and climate change
    Module 2: Understanding climate data/ forecasts
b. IMPACT: Built heritage and impact of climate change
    Module 3: The impact of climate change on heritage

Module 4: Climate heterotopia and heritage

c. VULNERABILITY: heritage as a resource for climate change

Module 5: GIS and conceptual models for heritage and vulnerability management

Module 6: Climate vulnerability and risks

d. ADAPTATION: Resilient heritage solutions

Module 7: Climate change and heritage policies

Module 8: Practices

Final Essay: Heritage site as a study case (fieldwork) +discussion (carried out at the e-CREHA platform)

3.2.2 The Course Methodology

Architecture education in Europe is primarily based on the Anticipatory Learning Theory that attempts to solve problems through action and repetitive reflection on the results which is Problem-Based Learning (PBL). A prior knowledge of environmental problems and the examination of climate change case studies are both necessary for this approach. It provides students with opportunities to experience problems and explore knowledge, resulting in powerful learning experiences.[65]

e-CREHA project adopts the generative learning approach. In this approach, learning entails generating new knowledge from previously codified information. Generative learning expands capabilities, enhances creativity, addresses underlying causes, leads learners to look in new ways, think differently, and anticipate futures, re-constructs knowledge.[66] The correlation between cognitive (intuitive) and behavioral (experiential) elements of knowledge plays an important role in understanding the impacts of climate change on heritage and addressing them creatively.

Based on these considerations, e-CREHA takes a multidisciplinary approach to cultural heritage & climate change. Experts and scholars from different countries collaborate to prepare and execute the e-CREHA course. The course is being created by e-CREHA Consortium with a variety of expertise, including architecture, built environment, heritage studies, engineering, climate science, and software technologies, and informatics. Throughout the project, the coherency of the e-learning modules/materials will be checked by the partners and tested by the students in various activities. In order to develop practical and heritage-sensitive skills that are necessary for future architects, e-CREHA will assess the learning potential of games and documentaries and adapt didactic materials

[65] Inayatullah, S. (2006). Anticipatory action learning: Theory and practice. Futures, 38(6), 656–666. https://doi.org/10.1016/j.futures.2005.10.003

[66] Carnerio, R. (2010) Open Educational Practices and Generativism. http://cloudworks.ac.uk/cloud/view/3827; Steffens, K. (2015). "Competences, Learning Theories and MOOCs: Recent Developments in Lifelong Learning" *European Journal of Education*,Vol.50,No.1,2015 DOI: 10.1111/ejed.12102

accordingly. The implementation of the course will be coordinated via the e-CREHA online platform.

Games are effective and innovative learning tools. The utilization of games in academic platforms through different media such as serious video games designed for educational purposes can be effective and engaging. Game-based learning approach (GBL) that draws on personal experience and experimentation allows the learning content to be personalized interactively. The games provide students with the opportunity to develop skills and knowledge as well as increase their capability to handle learning experiences.[67] Educational video games are successful in meeting the needs of autonomous learning in a non-formal context, as well as the freedom to choose the speed, time, and place of learning. In addition, such games meet modern needs for problem-solving, systemic thinking, and cooperation among learners.[68] As a tool for experiential learning (EL)[69], learning by doing, video maze games are the relevant genre of video games for learning history and cultural heritage.

The e-learning course will consist of maze games that will allow master students of the built environment to develop new (technical and soft) skills in order to build a resilient built environment in Europe. E-CREHA develops four serious games on resilient cultural heritage to be used as part of its course. Addressing the concepts of Resilience, Impact, Vulnerability, and Adaptation, maze games will contain puzzle mini-games embedded into maze halls and a variety of levels that allow for individualized didactic content and degree of difficulty. Furthermore, some of the maze games will include intelligent virtual players coded via machine learning algorithms. These players will answer student questions about the learning domain, in a plausible and believable way. The CDP report makes a survey of GBL related to climate change and cultural heritage.

In addition to games as a pedagogical tool, documentaries and videos can also be effective learning tools. Through their visual, auditory, and narrative experiences, they can reach and influence their audience regarding climate change. They are the means of transferring information, better understanding of the topic, and arousing curiosity about contemporary

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[67] Abdul Jabbar, A.I. and Felicia, P. (2015) "Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review, "*Review of Educational Research* 85, 4, 740-779, 767; Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., Martínez-Herráiz, J.J. (2013) "Gamifying learning experiences: Practical implications and outcomes." *Computers & Education*. 63, 380-392. http://dx.doi.org/10.1016/j.compedu.2012.12.020

[68] De Gloria, A., Bellotti, F., & Berta, R. (2014). Serious Games for education and training. *International Journal of Serious Games*, *1*(1). https://doi.org/10.17083/ijsg.v1i1.11; Papastergiou, M. (2009) "Digital Game-Based Learning in high school Computer Science education: Impact on effectiveness and student motivation." Computer and Education 52, 1-12. 10.1016/j.compedeu.2008.06.004
Karner, F.W., Härtel, G. (2010) Theory and Taxonomies of Serious Games. ENTRExplorer, 2010-1-PT1-LEO05-05190 Correlation (entrexplorer.com)

[69] Kolb, D. (2015) *Experiential Learning. Experience as the Source of Learning and Development,* 2nd ed. New Jersey, Pearson Education.

issues.[70] Digital platforms enable easy access to documentaries, which allows viewers to re-watch them. Documentaries can create a useful learning environment and act as an effective tool for innovative learning in the curriculum.[71] In that sense, videos about cultural heritage can be used for many purposes in education. These purposes include illustrating artifacts' properties, explaining their techniques, visualizing simulations of changes, sharing best practices, and promoting best practices. Even though videos assist mastery learning, they are primarily for inspiration rather than for immediate action. Today's challenging social and economic environment requires critical thinkers to succeed. Critical thinkers tend to see opportunities rather than problems. To promote critical thinking on resilient cultural heritage, e-CREHA will produce video clips that focus on Resilience, Impact, Vulnerability, and Adaptation. These audiovisual materials for learning/teaching/training will be integrated to the course content. The e-CREHA project will utilize the three 'I's Framework as an analytical approach, which is a combination of Image, Interactivity and Integration.[72] Accordingly, video becomes a networked teaching tool instead of a presentation tool:

a) Image: video focuses on the production of the image that should capture the subtle characteristics of the filmed subject.
b) Interaction: video on a case study focuses on the asynchronous access to the resources, ensuring that students can interact successfully with the material.
c) Integration: video can be used to support spreadsheet calculation programs, an Excel-based simulation, as an example. The key is the integration of the video with other applications.

Using pedagogical videos and traditional teaching approaches for learning climate resilient heritage is expected to improve both efficiency and effectiveness of learning. Materials produced by video should allow for multiple uses while maintaining their intellectual and educational value over time. e-CREHA will use (free of charge) the series of documentaries "Gebruikte Stenen Brabant" [Brabant's Used Bricks] to produce four new videos on building resilience to climate risks for cultural heritage.[73]

Climate change is a complex issue to study that requires involvement of many institutions, organizations, states: HEIs, local, regional, or national heritage associations, trusts and architecture education institutes, national/international professional organizations such as

[70] Liu, S. (2018) "Environmental Education through Documentaries: Assessing Learning Outcomes of a General Environmental Studies Course" *Eurasia Journal of Mathematics, Science and Technology Education* 1484):1371-1381. 10.29333/ejmste/83653; Korkut, Ş. Dornberger,Prajakta Diwanji, Bindu Puthur Simon and Michael Märki (2014) "Success Factors of Online Learning Videos" http://dx.doi.org/10.3991/ijim.v9i4.4460

[71] Karppinen, P. (2005). Meaningful learning with digital and online videos: Theoretical perspectives. *AACE Journa*l, 13(3), 233-250.

[72] Asensio, M., & Young, C. (2002). A learning and teaching perspective. In S. Thornhill, M. Asensio, & C. Young (Eds.), Click and go video. Video streaming—a guide for educational development. The JISC Click and Go Video Project, (pp. 10-19). Retrieved May 28, 2005, from video_streaming: a guide to educational development (ufrgs.br)

[73] Gebruikte Stenen Brabant'" is a twelve-episode production by Beeldland on industrial heritage in the Dutch province of Noord-Brabant, funded by non-commercial funds and by local governments.

ICOMOS, UNESCO etc. There should be a dialogue and collaboration between international and local, theory and practice, heritage community/climate scientists and policy makers. The four main categories of adaptation measures identified by IPCC are technological, behavioral, managerial, and lastly policy which can be measured by regulations, guidelines, and funding.[74]

A comprehensive EU strategy on adaptation to climate change was adopted by the EC very recently entitled "Forging a climate-resilient Europe". It is “a long-term vision for the EU to become a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050. This strategy aims to reinforce the adaptive capacity of the EU and the world and minimize vulnerability to the impacts of climate change. It aligns with the Paris Agreement and the proposal for a European Climate Law.[75] This will require the following steps:

- smarter adaptation: improving knowledge and managing uncertainty,
- more systemic adaptation: supporting policy development at all levels and in all relevant policy areas,
- faster adaptation: speeding up implementation across the board. [76]

There is a clear need for cooperation between a variety of specialized professionals with the necessary skills and knowledge. A link should be established between these strategies and education and accordingly, architecture curricula. There is a need to improve students' skills and competencies regarding EU actions. e-CREHA's e-learning course is designed to address these gaps. In an international professional environment, it is expected that students will develop problem-solving skills and experience different teaching-learning-working approaches. Tutors will develop new teaching skills, benefiting from the pedagogical exchange; professionals will acquire new sensitivity and alternative ways-of-doing from seminars and experimental designs developed in the academic environment.

3.2.3 The Course Objectives

e-CREHA course will be a transnational, accredited learning module that is compatible with European universities. It is designed to reach a wide range of students of the built environment with diverse cultures, knowledge backgrounds, and practices. The modules are formulated with strategies of integration of different disciplines. The course not only addresses key issues of climate change and resilience but also embraces social, and

[74] Intergovernmental Panel on Climate Change (IPCC). Climate Change 2007: Synthesis Report. Contribution of Working Groups i, ii and iii to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; IPCC: Geneva, Switzerland, 2007, 104.
[75] Climate ADAPT. (n.d.). EU Adaptation Strategy. Retrieved November 5, 2021, from https://climate-adapt.eea.europa.eu/eu-adaptation-policy/strategy
[76] Ibid.

economical aspects. It expands students' intellectual resources and builds a new climate-sensitive set of skills. The course offers clear and up-to-date communication techniques, as well as theoretical and practical knowledge from different disciplines. The students will also develop critical-analysis strategies for the recognition of heritage as a catalyst and driver of sustainable development in their future professional actions.

Thus, the e-CREHA course will have materials to learn resilient cultural heritage that are prepared and executed by a multidisciplinary, international team. It adopts a blending learning approach where the students will combine theoretical knowledge gathered from the e-course and practical skills learned on the field. Students from each partner university can access the materials (free of charge) through previous registration. When the course is completed, students will receive 5 ECTs. Innovative aspects of the e-CREHA course are its methodological approach and content on climate resilient heritage by linking educational methods with professional needs.

4. ANALYSIS

4.1. Methodology

The first intellectual output titled “Cross-disciplinary Pedagogies” (CDP) is a comprehensive survey and analysis of existing interdisciplinary learning/teaching methods and pedagogies with reference to following steps: introduction of the e-CREHA and Cross Disciplinary Pedagogies Report, identification of problem statement, background, methodology, research and analysis, and conclusion.

Implementation of e-CREHA e-learning course that is based on interactive methods encourages individual learning by means of different pedagogical approaches and encourages critical thinking to evaluate the subject. In order to develop a blended learning approach and set up a new/experimental course it is required to specify and assess new/current approaches, interpretations, and mediums in cross-disciplinary studies addressing climate change and built heritage by discovering four groups; current courses, games, documentaries, and climate plans and policies. Despite the needs outlined above, it is unknown how and to what extent heritage education relates to climate change and/or how heritage education can respond to climate change. CDP research addresses this gap.

The survey is adopted to identify methods and approaches of dealing with the subject by revealing the contextual, structural, and methodological forms that emerged in the context of the categories. It has been preferred since it is an accurate method of obtaining data by responding to questions created in a predetermined order and structure which helps in identifying the current situation; methods, gaps, problems searched on this particular issue. In that framework, a broad array of questions were listed and categorized in four groups including current courses, games, documentaries, and in addition climate governance and the role of plans and policies. For example, the following questions related to the courses, games, and documentaries/videos shed light on this research: in which disciplines are climate and heritage related issues studied? Are there collaborative studies addressing the issue to bring all the knowledge together? How are they geographically distributed? Which teaching, learning, and training methodologies are adopted? How do they approach the relevant issue? Which criteria are considered? What are the scope and objectives of those studies? Particularly related to the policies the following questions enable the necessary expansion; for what purposes the policies are implemented, scale, type, and impact of policies that may reveal the linkage between educational methods and professional needs.

The answers to all these critical questions provide data in the research which are analyzed and interpreted in the following parts.

The survey categorized in four groups was distributed to six partners of the e-CREHA project which is a joint platform of collaboration, co-learning and cooperation including universities, departments and research institutions extending across Europe. Via Google Document forms all the partners were asked to find courses, games, documentaries and climate plans and policies on the relevant subject focusing on their home countries. e-CREHA Consortium collected data after searching affiliated architecture/built environment schools and related academic institutions existing in their network. In some cases, the partners obtained data as a result of personal correspondence established via email. In addition, the partners responded to the questions by conducting research on the internet which is a practical way providing strong advantages of rapidly collecting a diverse and large-scale data. The relevant items were searched through most popular search engines (Google, Bing and Baidu), Web of Science, Scopus, some specialized online platforms like the European Climate Adaptation Platform online (Climate-ADAPT) to search policies and online learning platforms like Coursera to search the MOOC (Massive Open Online Course) in the period of February- August 2021.

Incoming data was collected in a specific template. The categories of the template are determined based on types of materials, course, game, documentary and policy. Each category is divided into various subtitles depending on its type. Subdivisions are formulated to classify content, structure, methodology, disciplinary approach etc.

In this research, three different types of research methods are adopted. The data is analyzed according to quantitative, qualitative analysis and SWOT analysis. Quantitative indicator is defined as the value of data in the form of numbers. Mathematical and statistical analysis of these numbers provide establishing some conclusive results depended on minimum personal bias. In this research, a quantitative indicator is specified to collect the data using a survey on the number of climate resilient heritage related three categories excluding policies. Data is visualized as tables and charts. Microsoft Office is utilized for its advantage in transmitting data clearly. Considering the inadequacy of a statistical evaluation lacking descriptive analysis, qualitative analysis was also considered necessary.

Qualitative indicator presents a holistic perspective of the subject in a descriptive method by means of the answers. Thus, all the data referring to the problems and key points are covered in the survey to be analyzed and interpreted in this research. Another tool of qualitative analysis is the reviews written by the partners of the project as “reflection paper”. A reflection paper was requested from each partner in which they evaluated the research process, aim/method for data collection, and the limitations of the research while

collecting data. The detailed examination of document/text analysis contributes to the validity of the research by providing data diversity.

Those two methods based on the survey and reflection papers are an effective way to measure impact by complementing each other. In order to make an accurate analysis, a SWOT analysis is also useful in providing a holistic picture on the issue and creating effective strategies for future plans. Identifying strengths, weaknesses (internal factors), opportunities and threats (external threats) is a strategic tool to prove the impact of climate change on the curriculum or on the education system related to the built environment. For this purpose, for CDP it is appropriate to make a SWOT analysis of each three categories (excluding policies) in order to identify the current limits and the new/integrative skills necessary to equip the future student. The whole research and data collection process through survey, as well as the contribution of the reflection papers, made it possible to do SWOT analysis. Overall, all the analysis helped to create a holistic perspective as well as become the vital tools for final remarks and correlations in this report.

4.2. Research and Analysis

4.2.1 Courses

Courses by country, institution, and year

As seen in Table 4.2.1-1 the courses were listed together with the institutions and the years in which they were offered. As their launching dates are not known, 19 courses are assumed to launch in 2021 and marked with an asterisk (*). Figure 4.2.1-1 shows the number of courses in each year. (We assumed that the courses would continue after they were opened.)

List of courses by country, institution, and year			
	Organizing institute	**Title**	**Year**
	Eindhoven University of Technology	Built-up Heritage Over time	2016-
	Eindhoven University of Technology	Graduation project-topic: Resilience and climate change	2017-2018-2019
	Eindhoven University of Technology	Master Project on Vulnerability	2020-
	Academie Rotterdam (RAvB)	Design course: de Haven van Antwerp	2021
	Academie Rotterdam (RAvB)	Design course: Nationaal Centrum Duurzaamheid	2021
	Academie Rotterdam (RAvB)	Design course: De Eeuw van de Amateur-Wildcard Studio-focus on vernacular architecture	2021
	Academie Rotterdam (RAvB)	Design course: Weerstudio	2021
	TUDelft (MOOC)	(Re)Imagining Port Cities: Understanding Space, Society and Culture	2021

NL	TU Delft	Heritage and architecture design studio: Research and Architectural Design	2021*
	Wageningen University	Design of Climate Change Mitigation and Adaptation Strategies	2021*
	Wageningen University	Climate-responsive planning and design	2015-
	University of Groningen	Adaptation Governance	2021*
	University Groningen-MOOC	Making Climate Adaptation Happen: Governing Transformation Strategies for Climate Change	2021*
	Coursera / United Cities and Local Governments of Africa African Local Government Academy Erasmus University Rotterdam Institute for Housing and Urban Development	Planning for Climate Change in African Cities	2021
	Coursera / University of Leiden	Heritage under Threat	2021
DE	BTU Cottbus	Heritage Impact Assessment	2017 -
	BTU Cottbus	Climate-adapted Construction and Operation	Summer 2021
ES	UNED (Universidad Nacional de Educación a Distancia)	Uncertainty and climate change. Challenges for a UNESCO world heritage city	Summer 2018
AR	ICOMOS Argentina, Fundación Ciudad de La Plata, Iniciativa Patrimonio y Cambio Climático (special event)	Climate Change and Risk Assessment for Cultural Heritage	2020-
IT	University of Venice -Conservation Science and Technology for Cultural Heritage (MD)	Geophysics and cultural heritage	2021*
	Politecnico di Torino - Architecture Heritage Preservation and Enhancement (MD)	Atelier Architectural restoration project (Science and technology of materials for restoration)	2021*
	Istituto per l'Arte e il Restauro - Master in Gestione e Conservazione del Patrimonio Mondiale	Cambiamenti Climatici e Impatto sul Paesaggio Naturale e Culturale	2021*
	Università di Bologna Laurea Magistrale in Science for the conservation - restoration of cultural heritage	Environmental Impact on Materials Deterioration and Aging	2021*
DK	Aarhus School of Architecture	Radical Sustainable Architecture	2021*
FI	Aalto University summer school	Climate Change, Health and Architecture	9-20.8.2021
TR	Kadir Has University/Turkey	KK 651 Dünya Mirası ve Alan Yönetimi (World Heritage and Site Management)	2020-
	Eskişehir Osmangazi University/ Turkey	Climate Change and Design	2018-...
FR	ENSA Bretagne	Architecture, Heritage and Eco-construction	2021*
	ENSA Normandie	Trans-form	2021*
	ENSA Toulouse	Heritage in Progress	2021*
	ENSA Toulouse	Construction and Durability	2021*
	INSA Strasbourg	"Climatic Heterotopias" STM-ARC-06-Projet d'architecture 1 et 2	2021*
	ENSA Strasbourg	Course on architectural heritage	2021*
	ENSA Clermont-Ferrand	TD de techniques patrimoniales d'intervention durable.	2021*

	ENSA Grenoble	Architecture and Heritage	2021*
	ENSAP Lille	Heritage and old buildings	2021*
	ENSA Marseille	Doctrines intervention on built environment	2021*

Table 4.2.1-1 Courses by country, institution, and year

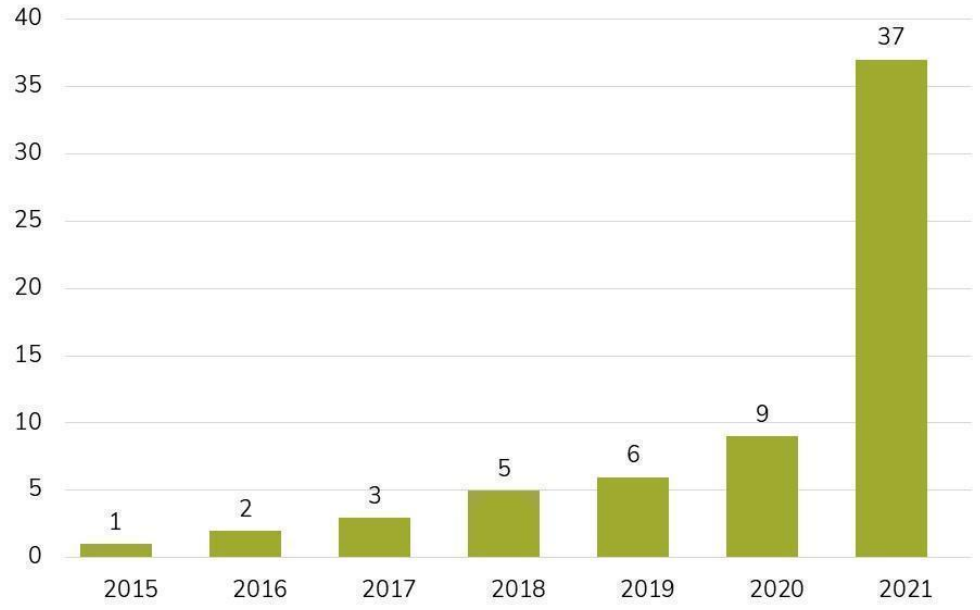

Figure 4.2.1-1 Number of courses by year

Number of courses offered in partners' home countries: 15 in the Netherlands, 10 in France, 4 in Italy, and 2 in Turkey. Figure 4.2.1-2 shows the distribution of courses by country.

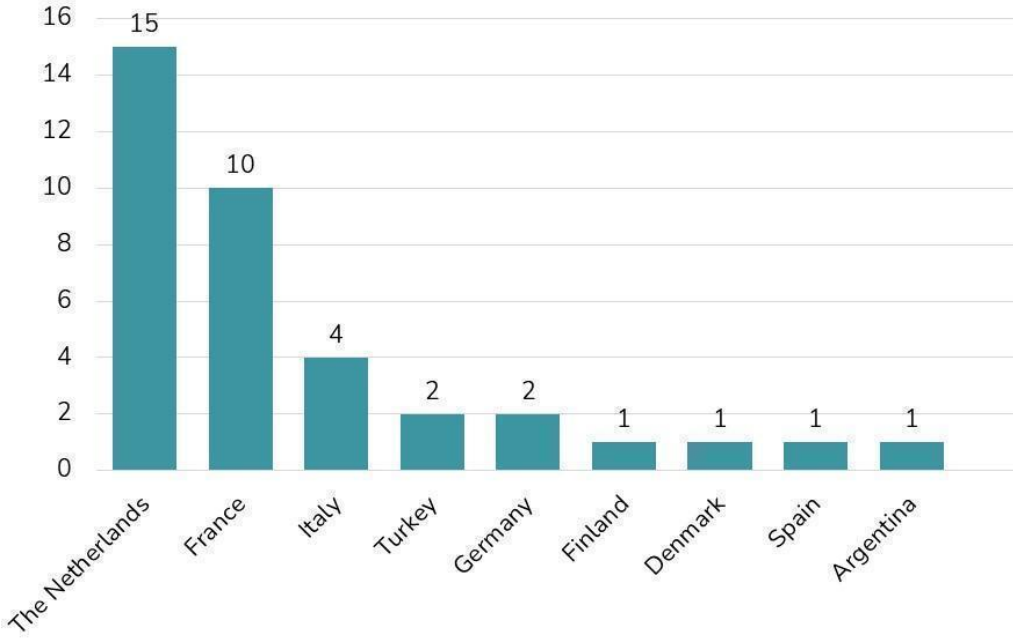

Figure 4.2.1-2 Distribution of courses by country

These courses are primarily offered by HEIs [Figure 4.2.1-3]. The only course offered by a non-HEI is “Climate Change and Risk Assessment for Cultural Heritage.” This MOOC course was made by ICOMOS Argentina. A MOOC entitled “Planning for Climate Change in African Cities” was created in collaboration between a HEI and a non-HEI, namely United Cities and Local Governments of Africa, African Local Government Academy, Erasmus University Rotterdam, and Institute for Housing and Urban Development.

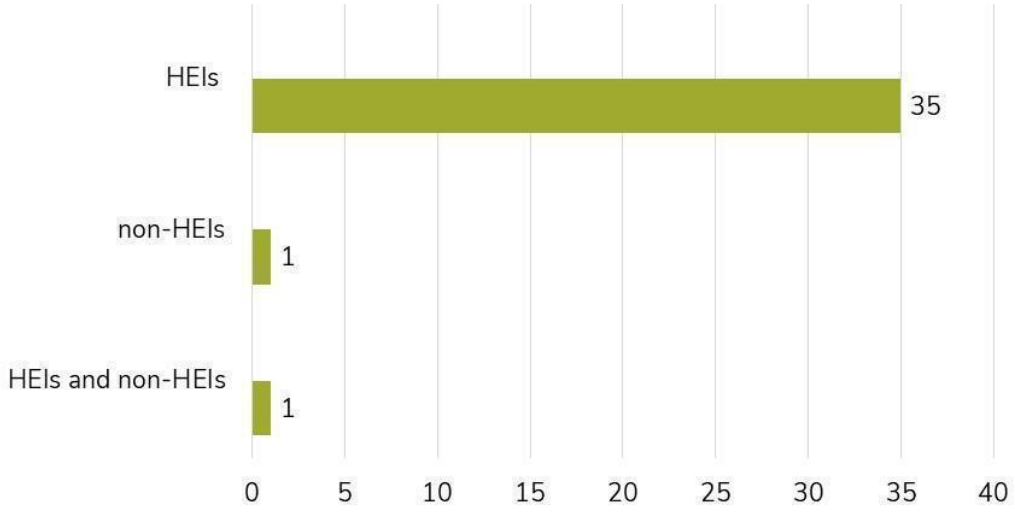

Figure 4.2.1-3 Number of courses offered by HEIs and non-HEIs

Course type, content, and target groups

There are four types of courses in our database: undergraduate, graduate, summer schools, and MOOCs [Figure 4.2.1-4].

There are both compulsory and elective courses in graduate and undergraduate programs [Figure 4.2.1-5]. A compulsory course is one that is required to complete a program. It is a key component in meeting the standards and objectives of the program. An elective course is the course that may be selected by students from a set of options in the curriculum. Our database includes two undergraduate courses, both compulsory: “Construction and Durability” by ENSA Toulouse and “Climatic Heterotopias” by INSA Strasburg. The course named "Construction and Durability" is designed for architecture students and focuses on different types of materials and their sustainability. “Climate Heterotopias” is an architectural studio that runs over two semesters in the fourth year. The course includes lectures on climate change. The course aims to provide students with experience in correlating philosophical and epistemological concepts to architectural production and industrial heritage in relation to climate change. The course is also offered to students of civil engineering, climatic engineering, and topography [Table 4.2.1-2].

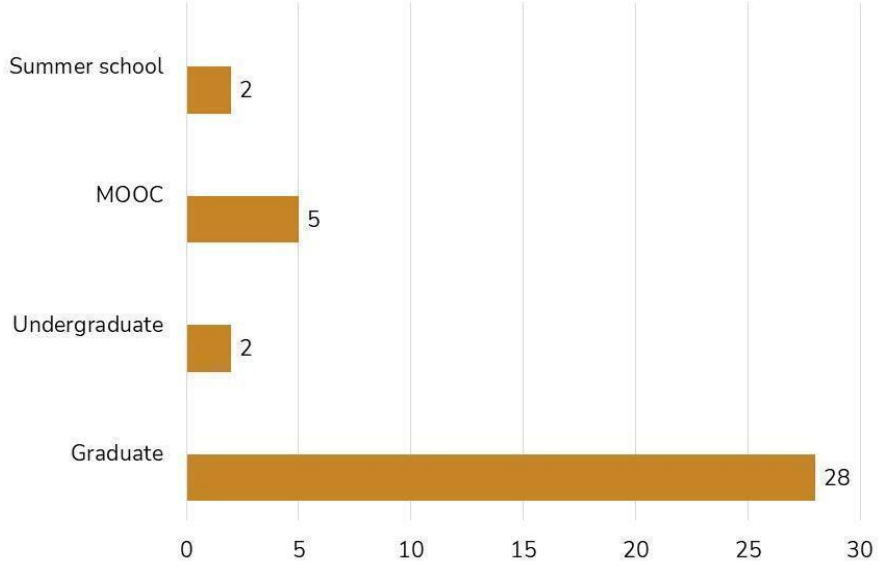

Figure 4.2.1-4 Course types by number

There are nine graduate compulsory courses in our database. They address climate change, either as an entire course or as part of a course [Table 4.2.1-3]. “Resilience and Climate Change" and "Master Project on Vulnerability," both are offered by the TU/e, and “Design Course: The Haven of Antwerp," given by the RAvB, are all design studios that address climate change and heritage. Architecture and urban planning programs offer them. Climate change and cultural heritage are addressed to some degree in the remaining compulsory graduate courses. [Table 4.2.1-9]. However, we were unable to determine their objectives, methods, and level of engagement with resilient cultural heritage.

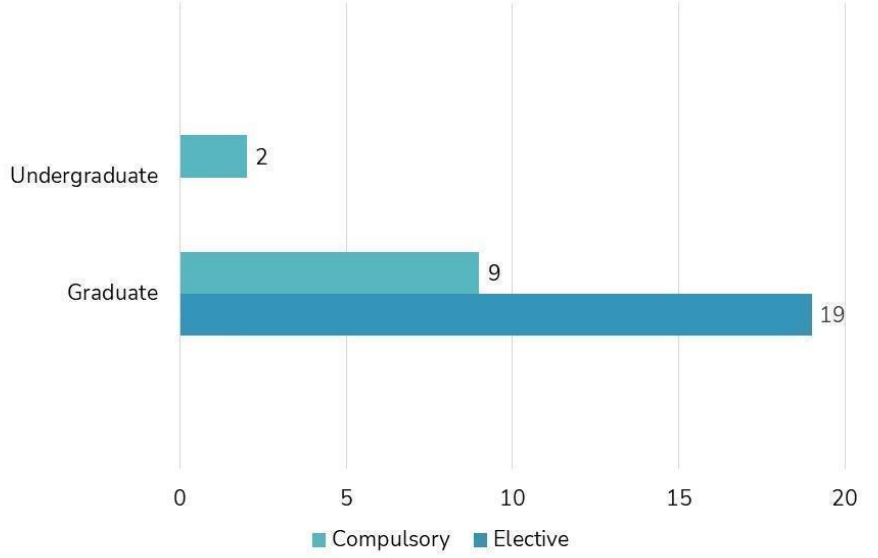

Figure 4.2.1-5 Numbers of compulsory and elective courses

Compulsory undergraduate courses		
Title of the course **University** **Target group of students**	**Scope of the course**	**Objectives**
Construction and Durability ENSA Toulouse / France Designed for undergraduate architecture students	Project workshops and lectures on structure and materiality of architecture	Discovery of a variety of different materialities and their **sustainability.**
"Climatic Heterotopias" **STM-ARC-06-Projet d'architecture 1 et 2** INSA Strasbourg/ France Designed for architecture - civil engineering-climatic engineering- topography	Project workshops + lectures on climate change. Students at the end of the semester are able to correlate in a concrete manner a philosophical and epistemological concept to architectural production and industrial heritage in relation to **climate change.** Intelligently and implicitly browse the different scales starting from the city scale to arrive in the building scale Investigate the architectural, urban and landscape dimension of urban farming and reinvest heritage Understand how innovation is shaped by architectural heritage and urban design Correlate innovation to its social dimension through space creation Develop a set of urban agriculture design guidelines adapted to their architectural concept.	Rehabilitation of an abandoned industrial heritage site. The fourth year Architectural Design Studio runs for two semesters, and it addresses the theme of "climatic heterotopia" in different architectural scales. The objective of the present module is the development of the perception of architecture as a specific discipline that deals with the treatment of space in urban scale, mobilizing a variety of different disciplines and engineering practices. Students at the end of the semester are able to: - correlate in a concrete manner a philosophical and epistemological concept to architectural production and building heritage - intelligently and implicitly browse the different scales starting from the city scale to arrive in the building scale - investigate the architectural, urban and landscape dimension of urban farming in relation to heritage - understand how innovation is shaped by architectural and urban design - correlate innovation and heritage to its social dimension through space creation - develop a set of urban agriculture design guidelines adapted to their architectural concept.

Table 4.2.1-2 Scope and objectives of compulsory undergraduate courses

Compulsory graduate courses in architecture, conservation and restoration, and urban planning programs		
Title **University** **Target group of students**	**Scope**	**Objectives**
Graduation project-topic: **Resilience and climate change** Eindhoven University of Technology)/The Netherlands Designed for architecture & urbanism students 4 adjoining quarters (8 weeks long each)	Goal of the design graduation studio is to formulate and analyze the meaning in use of resilient design principles, to investigate and explore resilient design strategies and techniques for the adaptation of existing buildings/heritage sites or development of new ones.	To carry out a careful reading of the site/heritage buildings-areas and their history in order to develop a critical perspective on the concept of adaptation and resilient design, their architectural and functional implications and their relationship to climate change
Master Project on Vulnerability Eindhoven University of Technology)/The Netherlands Designed for architecture & urbanism students 2 adjoining quarters (8 weeks long each)	Goal of the design studio is to cope rising water level, thus learning to designing with water while identifying and preserving heritage values in existing buildings/areas	To develop a critical perspective on the concept of vulnerability and adaptation through design, to comply with governmental spatial adaptations measures on flood areas and SDGs (goal 6, 11, 13)
Design course: de Haven van Antwerp Academie Rotterdam (RAvB)/The Netherlands Designed for architecture & urbanism students 2 adjoining quarters (8 weeks long each)	Goal of the design studio is to cope rising water level, thus learning to designing with water while identifying and preserving heritage values in existing buildings/areas	
Design course: De Eeuw van de Amateur-Wildcard Studio Academie Rotterdam (RAvB)/The Netherlands Designed for architecture & urbanism students	Focus on vernacular architecture	
Design course: Weerstudio Academie Rotterdam (RAvB)/The Netherlands Designed for architecture & urbanism students		
Design course: Nationaal Centrum Duurzaamheid Academie Rotterdam (RAvB)/The Netherlands Designed for architecture & urbanism students		

Atelier Architectural restoration project (Science and technology of materials for restoration) Politecnico di Torino - Architecture Heritage Preservation and Enhancement (MD) /Italy Designed for Architecture students 1 semester	The course is aimed at the analysis of degradation of materials and structures, at the understanding of the mechanisms of degradation and correlation with chemical, environmental and physical phenomena.	

Table 4.2.1-3 Scope and objectives of compulsory graduate courses in architecture, conservation and restoration, and urban planning programs

There are two graduate programs particularly formulated for climate adaptation and sustainability. *Climate-adapted Construction and Operation* is a research oriented full graduate program of 4 semesters offered by Brandenburg University of Technology (BTU) Cottbus/Germany. The program accepts graduates of Architecture, Civil Engineering, Building and Energy Technology. With an interdisciplinary approach, it focuses on the various aspects of climate-adapted construction both for new buildings and alterations to existing buildings. At Aarhus School of Architecture, *the Radical Sustainable Architecture Program focuses on* investigating and imagining architectural solutions to social, climatic, and environmental challenges [Table 4.2.1-4]. The courses of these programs are not published on the website. We assume that each offers at least one compulsory course addressing climate resilient heritage.

Graduate programs		
Title	**Scope**	**Objectives**
Climate-adapted Construction and Operation BTU Cottbus / Germany Designed for Architecture, Civil Engineering, Building and Energy Technology 4 semester, it is a master program	The programme 'Climate adapted Construction and Operation' teaches the building of energy and resource efficient buildings and their efficient operation. The teaching covers aspects of building design, building materials and technical building equipment, and in particular deals with the use of renewable energies. A special feature of the course is its **interdisciplinary** approach, which is reflected both in teaching and in the composition of the programme participants. Planning projects represent an important aspect of the study programme; here students can apply various aspects of **climate-adapted** construction in joint working groups. Both new buildings as well as the special features of existing buildings are taken into account. Academic work (master's project and master's thesis) can be carried out in connection with the current research projects of the faculty.	

Radical Sustainable Architecture Aarhus School of Architecture / Denmark	The programme is passionate about investigating and imagining architectural approaches to societal, climatic and environmental challenges in a rapidly changing world. We explore the making of space and our role within this process through emerging methods and tools both at different scales and in local and global contexts. We design for the needs and well-being of people, which is the foundation of a resilient and healthy environment.	Our emphasis is on examining how trans-disciplinary approaches involving anthropology, sociology, and psychology can qualify architectural design and how contextual influences such as politics, history, culture, ethics, climate/climate change, pollution, ecology, (scarce) resources, economy, technology, etc., can foster new qualities and imagination. These contextual influences inspire rather than inhibit architectural design.

Table 4.2.1-4 Graduate programs

"Climate Change, Health and Architecture" (by Aalto University, Finland) and "Uncertainty and Climate change: Challenges for a UNESCO World Heritage City" (by Universidad Nacional de Educación a Distancia, Spain) are summer schools [Table 4.2.1-5]. The first program aimed at the general public, including architects, designers, artists, planners, health professionals, policymakers, and activists with a focus on understanding climate change and its impacts on the built environment and human health. The second was a three-day program to raise public awareness. It is organized around the theme of climate change and aims to provide a space for open reflections on what a society of uncertainty means. It takes a variety of perspectives to do this: social movements, the media, experts, and science. It was broadcast live over the internet in order to reach a broader audience.

Summer schools		
Title	**Scope**	**Objectives**
Climate Change, Health and Architecture Aalto University **summer school**/ Finland Designed for architects, designers, artists, planners, health professionals, policy developers, activists 2 weeks (9.8.2021 - 20.8.2021)	Future-oriented introduction to climate change and its relationship to human activities, built environment and health. (The changing climate is causing increased stress to both buildings and their users. The built environment is also a key source of emissions. Meeting the goals of the Paris Agreement is not possible without strong action in construction. Climate change is also the underlying driver behind many threats to physical and mental health. This applies not only to humans but to most life on our planet. This course offers an evidence-based, clear and factual introduction to climate change and its relationship to human activities, built environment and health.)	Understanding the basics of climate change, including its causes and planetary boundaries Realizing the impacts of climate change on the built environment and human health Exploring and evaluating different future scenarios The role of construction as a driver and solution of climate change Key policy development paths The connections between carbon-neutral construction and wellbeing architecture Understanding the co-benefits of mitigation and adaptation strategies Learning to design and build for a better future and contribute to positive change.

Uncertainty and climate change. Challenges for a UNESCO world heritage city / Incertidumbre y cambio climático. Retos para una ciudad patrimonio cultural de la UNESCO UNED (Universidad Nacional de Educación a Distancia) /Spain (2018) 3 days (8 hours per day)	Taking climate change as its backbone, the course is constituted as a space for open reflection on what the society of uncertainty means. To do this, it takes different perspectives: social movements, the media, the professions or expert systems, and science. The course is broadcast live over the internet (streaming) with restricted access for those who do not travel to the center's facilities. The course can also be carried out on a deferred basis after the face-to-face sessions. Those people who want this modality will carry out verification work to obtain the certificate credits.	

Table 4.2.1-5 Scope and objectives of summer schools

There are 19 elective graduate courses in our database [Table 4.2.1-6]. TU/e's "Built-up Heritage Over Time" for architecture and urbanism students, examines the heritage impact assessments of architectural and urban development projects. The course is taught in lecture format. The effects of climate change on cultural heritage are discussed as part of the course. The focus is adaptation. "Heritage and Architecture Design Studio: Research and Architectural Design," by TU/Delft, focuses on design solutions for a cultural-historical context with an emphasis on adaptation and vulnerability. “Architecture and Heritage”, offered by ENSA Grenoble, includes both lectures and studios focused on reusing industrial heritage within an urban setting. ENSAP Lille's "Heritage and Old Buildings'' course also deals with technical aspects of renovation. The main concepts in these courses are resilience, vulnerability, and adaptation. “The Architecture, Heritage and Eco-construction” seminar by ENSA Bretagne includes a lecture series and a studio for residential buildings built after 1945. All these courses are designed for architecture, urbanism, and building science students. “Trans-form” by ENSA Normandie is one of the workshops of project and final diploma projects on rehabilitation of industrial heritage. It is offered to architecture and civil engineering students. The main concepts in these courses are resilience, vulnerability, and adaptation. Their focuses are on resilience, impact, and adaptation.

"Environmental Impact on Materials Deterioration and Aging" at the University of Bologna, focuses on the assessment of the microclimate indoor and outdoor environments for a sustainable protection. "Doctrines Intervention on Built Environment" is for architectural students at INSA Marseille. It is a project workshop on conservation. The course includes lectures and studio work. “TD de techniques patrimoniales d’intervention durable” by ENSA Clermont is a project workshop for architecture students. It involves lectures as well as studio work on sustainable intervention to heritage. INSA Strasburg offers “Course on Architectural Heritage” to architecture students. This course focuses on basic theories of restoration and rehabilitation and their evolution through lectures and studio work. Conservation of cultural heritage is the focus of the course "Geophysics and Cultural

Heritage" by the University of Venice Conservation Science and Technology for Cultural Heritage. The course entitled "World Heritage and Site Management" offered by Kadir Has University, focuses on the impact of climate change on world heritage and how to effectively protect it in one week of the entire semester. "Heritage Impact Assessment Transformation Strategies for Climate Change" by BTU Cottbus is for graduate students of Architecture, Environmental and Resource Management, Heritage Conservation and Site Management, Urban and Regional Planning, and World Heritage Studies. It consists of both lectures and studio sessions. “Climate Change and Design” offered by Eskişehir Osmangazi University considers climate resilience as a design factor in urban contexts.

"Climate-Responsive Planning and Design" offered by Wageningen University, is formulated for landscape architecture and spatial planning students. The course addresses the role of human activities affecting climate on the large spatial and temporal scale. Through this course, students learn to analyze and evaluate energy and urban climate systems to establish a basis for climate-responsible and energy-conscious planning and design interventions at various architectural scales.

Elective graduate courses in architecture, conservation and restoration, and urban planning, landscape planning programs		
Title	**Scope**	**Objectives**
Built-up Heritage Over Time Eindhoven University of Technology /The Netherlands Designed for architecture & urbanism students 1 quarter (8 weeks long)	This course aims to enable students to review retrospectively heritage impact assessments of architectural and urban development projects in regard to the heritage significance, and how they are integrated into the wider urban development agenda. By addressing key heritage-related topics this course enables the students to recognize the distinguished role of heritage in society and define what role transformation design and urbanization should play in global sustainability targets.	1.Skills – Perform and review retrospectively heritage impact assessments, by analyzing implemented (re)development projects, to assess their impact on the conservation of heritage resources (and climate change effects), and critically evaluate the results of the heritage impact assessments; recognize key principles of history of heritage and its distinguished role in society; 2. Knowledge – Describe and explain the rationale of heritage impact assessments in environmental management (why), the diversity of practices (what) and the relation between methods and results (how); 3. Attitude – Recognize, control and mitigate personal attitudes and biases on heritage impact assessments, within planning, architecture and engineering.

Heritage and Architecture Design studio: Research and Architectural Design TUDelf/The Netherlands Designed for architecture , urbanism & building science students	Re-designing and researching buildings of significance in cultural-historical context is the main concern of Heritage & Architecture. In this course the architectural research of existing built structures leads to conclusions that give the focus of the position and interpretation in a transformation or conservation design. The developing discussion in this studio by “Learning from others”, of theory and reference material is guiding for this re-design. Initially in small groups students research related questions to the proposed subjects for the transformation design. Students individually create a re-design that shows a meaningful translation of an intervention strategy into the spatial, functional, urban, material and technical design. The design choices are based on an understanding in relation to cultural value.	To convincingly present and discuss a coherent, significant, elaborated, correct and innovative design proposal on a mainline and on aspects relevant to the MSC2 level. -demonstrate the necessary argumentation skills to explain and reflect upon the relationships between analysis, conceptualization, method and composition of a design proposal for a cultural-historical context. -to understand the focus on moral sensibility, analysis, creativity and judgment skills regarding architectural ethics. - position the project within a particular theoretical, historical, social or contextual framework.
Climate-Responsive Planning and Design Wageningen University/The Netherlands Designed for Landscape architecture and spatial planning students 1 quarter (8 weeks)	This course addresses the role of human activities 'influencing' weather and climate on the large spatial and temporal scale, as well as for nested hierarchies of scales. These human activities have led to global warming, urban heat islands, urban wind nuisance, deteriorated human thermal comfort and contribute to the depletion of fossil fuel resources. In turn, one may limit these effects by careful design of renewable energy interventions and a climate responsive design of urban morphologies.	In this course, students get acquainted with the basic and advanced methods to reverse these adverse climate effects through the planning and design of both urban and rural landscapes. First, students acquire the scientific physical basis of energy systems and water cycles as drivers behind the urban climate. Second, the renewable energy sources and potential technologies are identified. Third, students learn to analyze and evaluate energy and urban climate systems. The results of the analyses form the basis for climate- responsive and energy-conscious planning and design interventions on various scale levels.
Heritage Impact Assessment Transformation Strategies for Climate Change BTU Cottbus / Germany Study Programmes Architecture, Environmental and Resource Mngmt, Heritage Conservation and Site Management, Urban and Regional Planning, World Heritage Studies	Based on the approaches established for environmental impact assessment, the course describes the phases required for assessing the type, scale and severity of impact that a proposed development project may have on heritage values. Students will understand the theories and practices required for informed impact assessment, mitigation and adaptation proposals, as well as development management and watch-briefs required for project implementation.	Understand the relationship between the Environmental Impact Assessment (EIA) and Heritage Impact Assessment (HIA) procedures; Understand the requirements for baseline studies and their significance for high-quality HIA; Apply relevant methodologies for impact assessment; Draw conclusions about the acceptability and feasibility of specific project proposals based on the impact assessment results; Develop recommendations concerning mitigation and adaptation measures.

1 semester long		
Geophysics and cultural heritage University of Venice Conservation Science and Technology for Cultural Heritage (MD) /Italy Designed for Architecture students 1 semester		Applied geophysics that are relevant for the diagnosis and conservation of cultural and artistic heritage
Environmental Impact on Materials Deterioration and Aging Università di Bologna Laurea Magistrale in Science for the conservation - restoration of cultural heritage / Italy Designed for international degree programme aimed at the education and training of Conservation Scientist (knowledge on chemistry, physics, biology, geology and informatics applied to cultural heritage and further knowledge in conservation)	Scope: basic information about environmental impact on the constituent materials in works of art; - methodologies for assessing the microclimate in indoor and outdoor environments for a sustainable protection of cultural artifacts and providing criteria and methodologies for assessing the environmental risk and vulnerability of cultural heritage at local, regional and national scale, including the impact of climate change; - Strategie di adattamento e mitigazione per la protezione del patrimonio culturale	
World Heritage and Site Management Kadir Has University/Turkey 1 week (Part of the 14 week long course)	The impact of climate change on world heritage and conservation methods against climate change	
Climate Change and Design Eskişehir Osmangazi University/ Turkey 14 weeks in a term	Design solutions in urban context with climate resiliency in mind.	The aim of the course is bringing the students in questioning the relations among diverse dimensions of design in urban context (visual, perceptual, morphological, social, functional, temporal dimensions and resiliency) and searching for climate resilient design solutions in any scale in urban environments in general.

Architecture, Heritage and Eco-construction ENSA Bretagne / France	Research seminars on the dimension of environmental heritage / Project workshop / lectures on theories of heritage / lectures on old buildings' constructive techniques.	"Renovation of condominiums residential buildings after 1945 "
Trans-form ENSA Normandie / France Architecture- Engineering/ Master in Civil Engineering, in co-authorization with the University of Le Havre.	Project workshops and final diplôma projects on rehabilitation of industrial heritage. TD on building pathologies and diagnosis.	Diagnostic and Rehabilitation of "Daily Architectures"
Course on Architectural Heritage INSA Strasbourg / France Designed for architectural students	Course on public policies and heritage theories Field of study "Project, history, heritage ".	Project workshop on a valuable building heritage. Courses on the basic theories about restoration and rehabilitation, and on their evolution.
TD de techniques patrimoniales d'intervention durable. ENSA Clermont-Ferrand/ France Designed for architectural students	Techniques, memory, architecture, urban and rural inhabited heritage.	Project workshops on building and existing neighborhoods. Research seminars on the notion of heritage
Architecture and Heritage ENSA Grenoble / France Designed for architectural students	Focus on reconversion of industrial heritage within urban context	Project workshop on heritage. Focus on an existing building within an urban context. Lectures on industrial heritage and reconversion.
Heritage and Old Buildings ENSAP Lille / France Designed for architectural students	Materiality and heritage / principles on intervention on heritage buildings / technical aspects of renovation	Project workshop on heritage reconversion and renovation / Lectures on materiality, structure and heritage
Doctrines Intervention on Built Environment INSA Marseille /France Designed for architectural students	Project workshops on ruins, town centers, monuments and on architecture of the 20th century. Lectures on methods of analysis of the state of conservation of a building. Research seminars on the methods of transmission.	Project workshops on building and existing neighborhoods. Research seminars on the notion of heritage

Table 4.2.1-6 Scope and objectives of elective graduate courses in architecture, conservation and restoration, landscape planning and urban planning programs.

Wageningen University's "Design of Climate Change Mitigation and Adaptation Strategies" is a course for Water Systems and Global Change studies that discusses climate change as an ethical issue. "Adaptation Governance" by University of Groningen examines climate-driven migration. These climate science courses do not address built heritage directly [Table 4.2.1-7].

Courses for climate studies and cultural geography students	
Title	**Scope**
Design of Climate Change Mitigation and Adaptation Strategies Wageningen University/The Netherlands Designed for water systems and global change, climate studies students 1 quarter	Teams of 4 to 7 students will work in multidisciplinary teams in a consultancy project. The teams are composed on the basis of students' interests and the required disciplinary mix for the execution of the project. Students have to express their interest for a particular project in an application letter addressed to the course lecturers. The projects are related to climate change mitigation and adaptation issues; the commissioner can be a local, regional (province) or a national government (ministry), international NGOs, national institutions like 'Rijkswaterstaat' or regional water authorities, research institutes, public organizations or private companies. Each team is responsible for dividing the tasks among its members, communicating with the commissioner, and developing the final design or solution that will be presented. Each team has an assigned coach and is required to find at least one content coach or expert relevant to the project. In this course students also study and discuss climate change as a moral problem that raises ethical questions about personal and societal obligations. What is a fair distribution of the burdens of mitigating climate change now and in the future? Can we have obligations to future people at all? How to deal with scientific uncertainty in relation to the effects of global warming? And what ethical values and principles should be taken into account in judging what mitigation or adaptation interventions are morally permissible?Parallel to their projects, students follow tutorials on report writing (structure, style and language) and practice their report writing skills.
Adaptation Governance (cultural landscapes) University of Groningen /The Netherlands Designed for cultural geography students 1 quarter (8 weeks)	Adaptation Governance introduces you to the effects of climate change, and developments in adaptation governance. It contains the first of three classes on climate driven migration.

Table 4.2.1-7 Courses for climate studies and cultural geography students.

The number of MOOCs is 5 that are offered by the institutions of the Netherlands and Argentina [Table 4.2.1-8]. “Making Climate Adaptation Happen” by University Groningen discusses climate impacts and adaptation based on scientific facts and terminology. The MOOC named "(Re)Imagining Port Cities: Understanding Space, Society, and Culture"

covers the issues port cities face in the past and today and how to plan for a sustainable and socially just port city by following the UN SDGs. Developed by a consortium of academies and local stakeholders, "Planning for Climate Change in African Cities" examines the impacts, impacts, and drivers of climate change on cities. The course introduces methods and approaches that can be used to understand how climate change affects urban risk and vulnerability and explains the diverse typologies, approaches, and tensions of climate change adaptation. "Heritage Under Threat" from Leiden University's Centre for Global Heritage and Development discusses the factors contributing to destruction or threats to heritage, such as war, terrorism, migration, global warming, financial crises, inequality, and diverse interests of local communities. Despite being developed by a non-European organization, "Climate Change and Risk Assessment for Cultural Heritage" by ICOMOS Argentina is included in our database as an example, since it is directly related to climate change and resilient heritage. This e-learning course has been created by inter-disciplinary experts to provide participants with the tools necessary to assess the risks to which their cultural heritage is exposed.

MOOCs		
Title	**Scope**	**Objective**
Making Climate Adaptation Happen University Groningen /The Netherlands 4 weeks (4 hours in each week)	Introduction to climate science, the societal effects of climate change, and the responses already available in the form of climate adaptation. Identify why climate change adaptation is important Adaptive governance is a term used to describe an approach to managing the uncertainty posed by rapid environmental changes in a more responsive manner than traditional modes of governance. As such, it could be a vital governance tool in the fight against climate change. Being able to nimbly react to fast-changing environmental crises requires certain skill sets that many governing bodies currently lack. Create a climate change adaptation plan Learning alongside experts in governance and adaptation strategies, you'll examine the science behind climate change, exploring the terminology and facts behind what it is and how we adapt to it. You'll summarize the development of the current architecture of global governance for dealing with climate change. Exploring the costs and benefits of climate adaptation versus climate mitigation, you'll identify the governance and social science theories that can help tackle environmental change, and	At the end of this course, you will be able to: Describe the natural science background of climate impacts and climate adaptation based on scientific facts and terminology.

	the role international climate finance can play. Topics: Climate science and controversies. Climate adaptation governance; Climate finance; Nature-based solutions Learning goals: -Describe the natural science background of climate impacts and climate adaptation based on scientific facts and terminology. summarize the historical development of the global governance architecture for climate adaptation.; Identify relevant governance and social science theories in the context of climate adaptation.; Reflect on the role of international climate finance for climate adaptation; Assess climate adaptation governance from an integrated and global vantage point.	
Planning for Climate Change in African Cities. Coursera Intermediate Level United Cities and Local Governments of Africa African Local Government Academy Erasmus University Rotterdam Institute for Housing and Urban Development 5 weeks (Approximately 22 hrs.)	Climate change poses a threat to economic growth and long-term prosperity of many countries around the world. Africa is not an exception, considering the actual and potential impacts of climate change and climate variability that will threaten its vulnerable sectors and human populations. African countries are projected to experience changing rainfall patterns, rising sea levels, and higher temperatures that will affect food security, agricultural production, water availability, and public health, among others. These climate change impacts, and climate variability can further produce social and political problems, such as rural-urban migration and water resource disputes.	Recognize the effects, impacts, and drivers of climate change in cities. Understand the drivers of urban risk and vulnerability in the context of climate change. Distinguish the typologies, approaches, and tensions of climate change adaptation. Explain the different approaches and steps in climate change planning. Examine the decision support and assessment tools for climate change. Develop a climate change plan based on participants? city contexts
Heritage under Threat Coursera Beginner Level Universiteit Leiden Centre for Global Heritage and Development 6 weeks (Approximately 29 hours)	In this course you will learn to articulate your own concepts about (threatened) heritage and that of others. What is your heritage? Who defines heritage? Why is heritage under threat? How can we protect heritage? WW1, WW2, Cold war politics and contemporary conflicts as well as continuing political and socio-economic inequalities and colonial pasts are all factors playing a role in the global heritage discussions and approaches to (or lack of) valorization and protection of heritage. Hence, issues behind destruction or threats to heritage are related to complex issues, often connected to complex landscapes of wars, the war-on-terror, fundamentalism, migration, global warming, financial crises, inequality, and diverse interests of local communities.	To engage global communities and widen the perspective on threatened heritage

Climate Change and Risk Assessment for Cultural Heritage ICOMOS Argentina Designed for Graduates and students of technical and university careers linked to the management of cultural heritage. Professionals in architecture, design, museology, conservation, restoration, related specialties, cultural managers and public officials. 10 weeks (30 hours)		Considering the current climate emergency and its impact on heritage conservation, the general objective of this virtual course is for participants to acquire tools to characterize a cultural institution based on the analysis of its building and its collections, in order to evaluate the risk to which its heritage is exposed.
(Re)Imagining Port Cities: Understanding Space, Society and Culture TUDelft / The Netherlands EdX 5 weeks (4-5 hours each week)	Port cities are dynamic environments. They face ever-changing challenges and demands from port activities under continually evolving economic and environmental circumstances. They also offer a rich social and cultural environment. If you are a professional involved in the development and running of port cities this course will offer you a fresh perspective on the complex spatial and socio-cultural relations between ports, cities, and regions and between water and land, around the world. This course will provide you with the insights and tools to understand and transform port city regions. By employing a comprehensive cross-cultural perspective, you will make better decisions when addressing the challenges port cities face today and when planning for a sustainable and socially just future of your port city in line with the UN Sustainable Development Goals. If you are a master level student with an interest in a multidisciplinary approach to the development of cities, with a connection to the built and natural environment this course will offer you an insight into the workings of port city development, preparing you better for a possible career in this area. If you live in a port city this course will help you understand the development of your city, appreciate the hidden potential, and help you influence the way your port city deals with issues such as climate change and rising water levels in the future.	After taking this course, you will be able to: Recognize port cities as a particular type of space and appreciate their defining characteristics. Analyze the complexity of the networks of stakeholders in port cities. Analyze moments of change in port cities both global and local and their causes and effects. Reflect on contemporary social, economic, and environmental challenges and the way decisions taken in the past are still influencing the present and the future. Assemble a value-based approach to decision-making in port cities for sustainable development and the benefit of all relevant stakeholders.

Table 4.2.1-8 MOOCs

Learning environments and methods

The teaching methods of courses either lecture based or studio, or a combination of those two are shown in Fig.4.2.1-6.

All of the graduate and undergraduate courses are in-class courses. Among them, two courses, “Heritage Impact Assessment “by BTU Cottbus and “Uncertainty and Climate Change: Challenges for a UNESCO Cultural Heritage City” by UNED combines in-class learning with e-learning. MOOC courses and Aalto University's Summer School on “Climate Change, Health, and Architecture” are online courses.

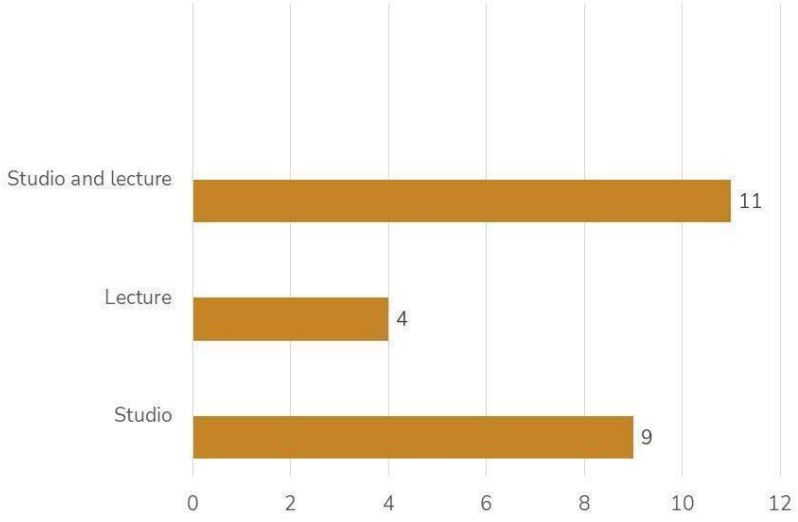

Figure 4.2.1-6 Methods of the courses

Resilience, Impact, Vulnerability, and Adaptation

Table 4.2.1-9 lists the courses according to the target group of students, and identifies which of the concepts "Resilience", "Impact", "Vulnerability", and "Adaptation" they address.

Course types and their focus on Resilience, Impact, Vulnerability, and Adaptation **Target group of students** **Lecture or studio**							
	Title	**Target Group of Students**	**Lecture Studio**	**R**	**I**	**V**	**A**
Compulsory undergraduate courses	**Construction and Durability** ENSA Toulouse / France	Architecture	Lecture & Studio	✓	✓	✓	✓
	Climatic Heterotopias STM-ARC-06-Projet d'architecture 1 et 2 INSA Strasbourg/ France	Architecture Civil engineering Climatic engineering	Lecture & Studio	✓	✓	✓	✓

Compulsory courses of architecture, conservation, and urban planning graduate programs	**Resilience and climate change** Eindhoven University of Technology)/The Netherlands	Architecture Urbanism	Studio	✓			✓
	Master Project on Vulnerability TU/e / The Netherlands	Architecture Urbanism	Studio	✓		✓	
	Design course: de Haven van Antwerp RAvB / The Netherlands	Architecture Urbanism	Studio		✓		✓
	Design course: De Eeuw van de Amateur-Wildcard Studio RAvB / The Netherlands	Architecture Urbanism	Studio				✓
	Design course: Nationaal Centrum Duurzaamheid RAvB / The Netherlands	Architecture Urbanism	Studio		✓		
	Design course: Weerstudio RAvB / The Netherlands	Architecture and urbanism	Studio			✓	
	Atelier Architectural restoration project Science and technology of Materials for Restoration Politecnico di Torino-Architecture Heritage Preservation and Enhancement (MD) / Italy	Architecture Heritage Preservation and Enhancement	Not available		✓		✓
	Radical Sustainable Architecture Aarhus School of Architecture / Denmark **Master Program**	Not available	Not available	✓			
	Climate-adapted Construction and Operation Master Program BTU Cottbus / Germany **Master Program**	Architecture Civil Engineering, Building and Energy Technology	Lecture & Studio				✓
Elective courses of architecture, conservation and urban planning graduate programs	**Built-up Heritage Over Time** TU/e / The Netherlands	Architecture Urbanism	Lecture				✓
	Heritage and Architecture Design Studio: Research and Architectural Design TU Delft / The Netherlands	Architecture Urbanism Building Science	Studio			✓	✓
	Architecture and Heritage ENSA Grenoble / France	Architecture	Lecture & Studio	✓		✓	✓
	Heritage and Old Buildings	Architecture	Lecture &	✓		✓	✓

	ENSAP Lille / France		Studio				
	Architecture, Heritage and Eco-construction ENSA Bretagne / France	NA	Lecture & Studio	✓	✓		✓
	Trans-form ENSA Normandie / France	Architecture Civil Engineering	Lecture & Studio	✓	✓		✓
	Environmental Impact on Materials Deterioration and Aging Università di Bologna Laurea Magistrale in Science for the conservation - restoration of cultural heritage / Italy	Conservation science	Lecture		✓	✓	
	Doctrines Intervention on Built Environment ENSA Marseille / France	Architecture	Lecture & Studio	✓		✓	✓
	TD de techniques patrimoniales d'intervention durable ENSA Clermont-Ferrand / France	Architecture	Lecture & Studio	✓		✓	✓
	Course on Architectural Heritage ENSA Strasbourg / France	Architecture	Lecture & Studio	✓			✓
	Geophysics and Cultural Heritage University of Venice -Conservation Science and Technology for Cultural Heritage (MD) / Italy	Architecture	Not available	✓	✓	✓	✓
	Climate Change Impact on Natural and Cultural Landscape / Institute for Art and Restoration	Management and Conservation of World Heritage Master Program	Not available		✓	✓	
	World Heritage and Site Management Kadir Has University / Turkey	Graduate School of Science and Engineering	Lecture	✓	✓	✓	✓
	Climate Change and Design Eskişehir Osmangazi University / Turkey	Architecture	Lecture	✓	✓	✓	✓

	Heritage Impact Assessment Transformation Strategies for Climate Change BTU Cottbus / Germany	Architecture Environmental and Resource Management Heritage Conservation and Site Management Urban and Regional Planning World Heritage Studies.	Lecture and Studio In class & e learning	✓			
	Climate-Responsive Planning and Design Wageningen University / The Netherlands	Landscape architecture Spatial planning	Studio				✓
Climate Studies **Cultural Geography**	**Design of Climate Change Mitigation and Adaptation Strategies** Wageningen University /The Netherlands	Water Systems and Global Change Climate Studies	Studio	✓			✓
	Adaptation Governance University of Groningen Master in Climate Adaptive Governance	Cultural geography	Lecture				✓
MOOCs	**Making Climate Adaptation Happen** University Groningen /The Netherlands Future Learn	Sustainable entrepreneurship and business model innovation in sensitive ecologies climate adaptation	Not available	-	-	-	-
	(Re)Imagining Port Cities: Understanding Space, Society and Culture TUDelft / The Netherlands	History of Architecture Architecture Urban planning	Not available		✓	✓	✓
	Planning for Climate Change in African Cities Coursera United Cities and Local Governments of Africa African Local Government Academy Erasmus University Rotterdam Institute for Housing and Urban Development	Climate change and risk adaptation expert Social scientist, Environmental economist Climate change expert Geographer Urban regional planner Climate change vulnerability and resilience expert Expert of vulnerability of urban systems	Not available	✓	✓	✓	✓
	Heritage under Threat Coursera Universiteit Leiden Centre for Global Heritage and Development	Archeology and ethnography	Not available		✓		

	Climate Change and Risk Assessment for Cultural Heritage ICOMOS Argentina	Professionals in architecture, design, museology, conservation, restoration, related specialties, cultural managers and public officials.	Not available			✓	

Table 4.2.1-9 Course types and their focus on Resilience, Impact, Vulnerability, and Adaptation

Figure 4.2.1-7 displays the groups of concepts of Resilience, Impact, Vulnerability, and Adaptation in our database and the frequency of each group.

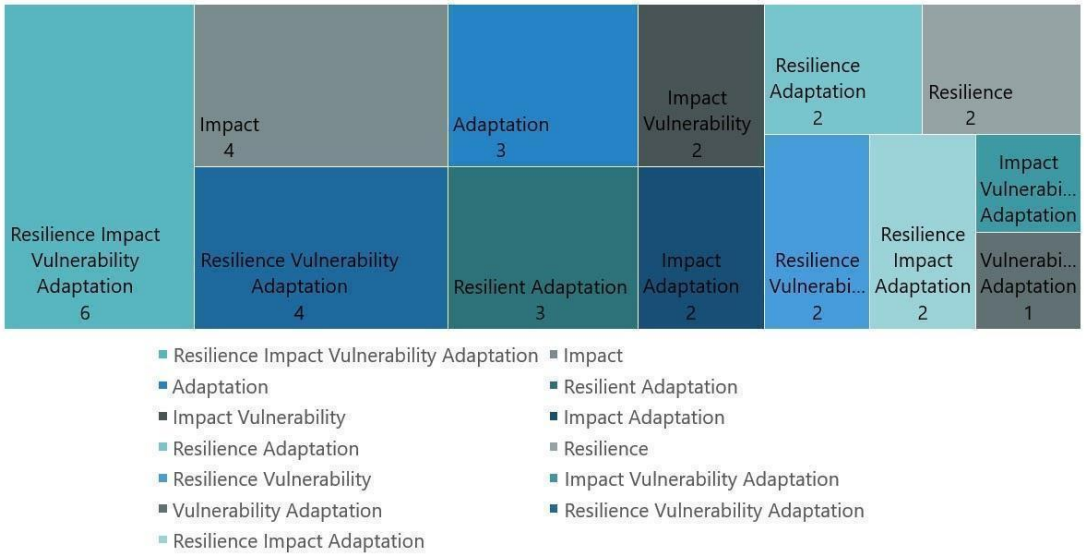

Figure 4.2.1-7 Groups and frequency of concepts

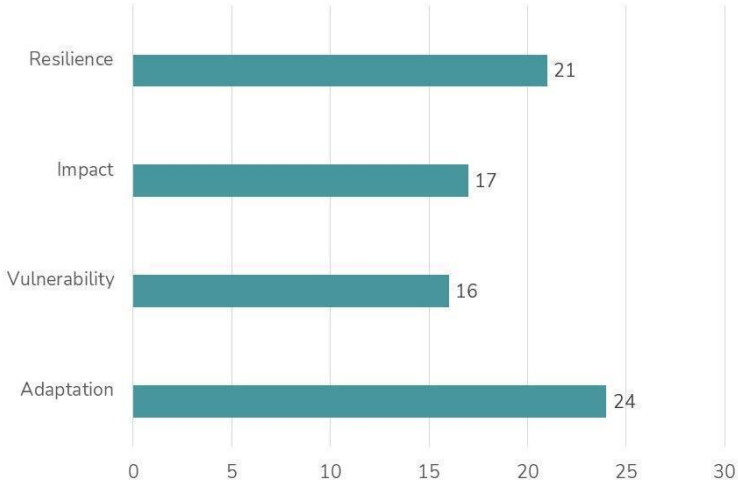

Figure 4.2.1-8 Frequency of concepts

Expertise areas of tutors and interdisciplinarity of courses

Table 4.2.1-10 outlines the extent of interdisciplinarity among the courses. The table includes the number of tutors who developed courses, their areas of expertise, and the target groups of students for whom the courses are formulated. Figure 4.2.1-7 shows tutors' expertise. The analysis included courses listed in Table 4.2.1-10, and other courses in our database were excluded since there is no information available about the expertise areas of their tutors.

Expertise areas of tutors, target group of students			
Title	**Tutors' expertise areas**	**# of in.**	**Target group of students**
Built-up Heritage Over time	Architect Landscape architecture History	3	Architecture Urbanism
Graduation project-topic: Resilience and Climate Change	Architect Landscape architecture History	3	Architecture Urbanism
Master Project on Vulnerability	Architect Landscape architecture	2	Architecture Urbanism
Design course: de Haven van Antwerp	Architecture Urban planning	3	
Design course: Nationaal Centrum Duurzaamheid	Architecture Urban planning	2	Architecture Urbanism
Design course: Weerstudio	Architecture Urban planning	3	Architecture Urbanism
(Re)Imagining Port Cities: Understanding Space, Society and Culture	Architecture History	9	Professionals and graduate students
Climate-responsive planning and design	Engineering	3	Landscape architecture Spatial planning
Atelier Architectural restoration project (Science and technology of materials for restoration)	Science and Engineering of Materials		
Atelier Architectural restoration project (Science and technology of materials for restoration)	Architecture Sustainability		
Planning for Climate Change in African Cities, MOOC	Tourism Environmental economy Environmental Policy Urban and regional planning Geo information	8	

	management Geography		
Heritage under Threat	Archaeology	1	
Heritage under Threat	Architecture Conservation and restoration	1	Restoration and conservation graduate program students
Climate Change and Design	Urban planning	1	Urban planner architects
Architecture, Heritage and Eco-construction	Architecture		
Trans-form	Architecture		Architecture Civil Engineering
Heritage in Progress	Architecture	2	Architecture
Construction and Durability	Architecture	1	Architecture
"Climatic Heterotopias"	Architecture Engineering	1 main 4 visitin	Architecture Civil Engineering Climatic Engineering Topography
Course on Architectural Heritage	Architecture		Architecture
Architecture and Heritage	Architecture		Architecture
Heritage and old buildings	Architecture		Architecture
Doctrines intervention on built environment	Architecture		Architecture

Table 4.2.1-10 Expertise areas of tutors, target group of students

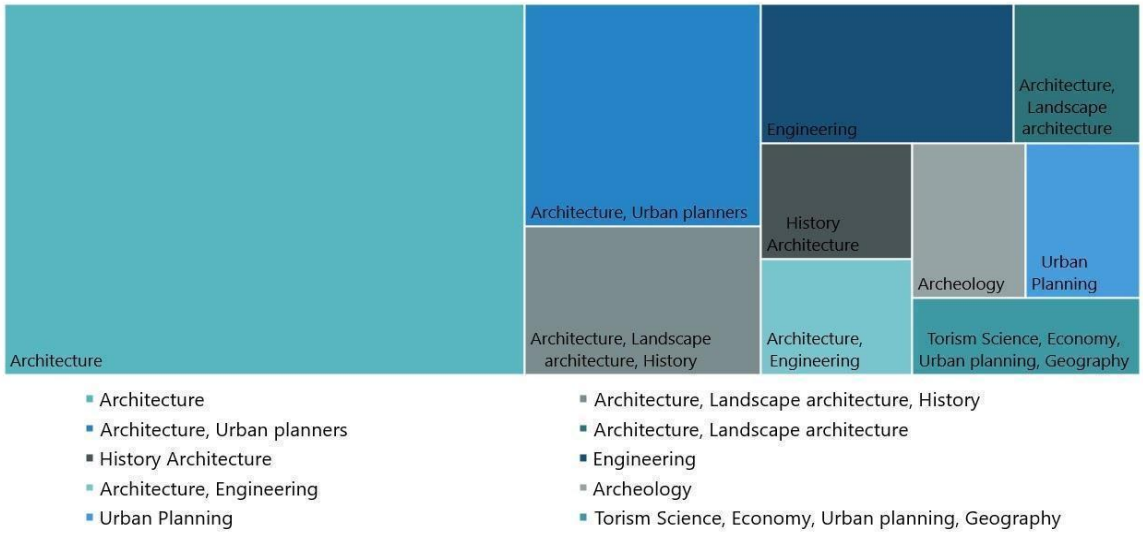

Figure 4.2.1-9 Disciplines of the tutors/Interdisciplinarity of course tutors

Courses according to their focus and extent of climate change and cultural heritage

In Table 4.2.1-11, courses are arranged according to their focus and extent of dealing with climate change and cultural heritage. The table includes 32 courses. Graduate programs, “Climate-adapted Construction and Operation” at BTU Cottbus and “Radical Sustainable Architecture” at Aarhus School of Architecture (Table 4.2.1-4) as well as design courses “Nationaal Centrum Duurzaamheid”, “De Eeuw van de Amateur-Wildcard Studio-focus on vernacular architecture” and “Weerstudio” by RAvB are excluded because we do not have sufficient information about their contents.

Categories of courses according to their focus and extent of climate change and cultural heritage	
Main focus of the courses	**Title of the courses**
A. The built environment and climate change courses	
A1. Built environment courses neither climate change nor heritage is the main focus Climate change impact on heritage is one of the issues discussed	
Structure and materiality of architecture	• **Construction and Durability** (ENSA Toulouse)
A2. Courses with a focus on **built environment and climate change** Heritage is one of the issues discussed	
Climate resilient built environment.	• **Climatic Heterotopias** (INSA Strasbourg) • **Climate-adapted Construction and Operation** (BTU Cottbus) • **Radical Sustainable Architecture** (Aarhus School of Architecture) • **Climate Change and Design** (Eskişehir Osmangazi University) • **(Re)Imagining Port Cities: Understanding Space, Society and Culture** (TU Delft, MOOC by Edx)
A3. Courses on **built heritage** Climate change is just one of the issues addressed	
A3.1 Adaptation through transformation at various scales, including rehabilitation and retrofitting	• **Heritage and Architecture Design studio: Research and Architectural Design** (TU Delft) • **Architecture, Heritage and Eco-construction** (ENSA Bretagne) • **Heritage and Old Buildings** (ENSAP Lille) • **Trans-form** (ENSA Normandie) • **Architecture and Heritage** (ENSA Grenoble)
A3.2 Vulnerability, conservation, preservation, restoration	• **Geophysics and Cultural Heritage** (University of Venice Conservation Science and Technology for Cultural Heritage)

	• **Environmental Impact on Materials** Deterioration and Aging (Università di Bologna Laurea Magistrale in Science for the conservation - restoration of cultural heritage) • **Course on Architectural Heritage** (INSA Strasbourg) • **TD de techniques patrimoniales d'intervention durable** (ENSA Clermont-Ferrand) • **Doctrines Intervention on Built Environment** (INSA Marseille) • **Heritage under Threat** (Universiteit Leiden Centre for Global Heritage and Development, MOOC by Coursera) • **Atelier Architectural Restoration Project** (Politecnico di Torino) • **World Heritage and Site Management** (Kadir Has University)
A4. Built heritage and climate change courses	
A4.1 Vulnerability, adaptation and conservation	• **Climate Change and Risk Assessment for Cultural Heritage** (ICOMOS Argentina, MOOC) • **Heritage Impact Assessment Transformation Strategies for Climate Change** (BTU Cottbus)
A4.2 Adaptation and transformation	• **Master Project on Vulnerability** (TU/e) • **Design course: de Haven van Antwerp** (RAvB)
A4.3 Climate resilient heritage Heritage as an asset for mitigation and adaptation	• **Graduation project-topic: Resilience and climate change** (TU/e) • **Built-up Heritage Over Time** (TU/e)
B. Climate change courses Heritage is minimal or absent in the content	
Climate science. Social and geographic implications of climate change (content of the course based on both natural and social sciences) Built environment as an agent for mitigation or intensifying climate change.	• **Making Climate Adaptation Happen** (Wageningen University, MOOC) • **Climate Change, Health and Architecture(**Aalto University, Summer school) • **Uncertainty and Climate change. Challenges for a UNESCO World Heritage City** (UNED, Summer school) • **Design of Climate Change Mitigation and Adaptation Strategies** (Wageningen University) • **Adaptation Governance** (University of Groningen) • **Planning for Climate Change in African Cities** (United Cities and Local Governments of Africa, African Local Government Academy, Erasmus University Rotterdam, Institute for Housing and Urban Development, MOOC by Coursera) • **Climate-Responsive Planning and Design** (Wageningen University)

Table 4.2.1-11 Courses according to their focus and extent of climate change and cultural heritage

SWOT Analysis

Strengths • The topic of climate change and built heritage is covered in a number of courses. In architectural education, there is a growing awareness and an increasing interest in the subject of climate change and cultural heritage. • The MOOCs feature interdisciplinary content provided by experts on climate change and cultural heritage.	**Weaknesses** • Interdisciplinary expertise and approaches in the courses are limited in the current curricula. • The subject of climate resilient heritage is usually not covered extensively throughout the semester but is discussed as part of an overall course. • The role of built heritage for mitigation and adaptation is not often addressed. • The methods of teaching are not innovative. • Courses are not developed in collaboration with research.
Opportunities • E-courses can overcome restrictions of time and place. They can reach a larger group of students. • It is possible and efficient to integrate ICT tools into an innovative teaching method.	**Threats** • The study of climate change and built heritage has not become a specialized graduate program, so studies and publications are limited.

Results

As a result of our survey, we have reached 37 courses offered from institutions of 9 different countries [Table 4.2.1-1]. There is a greater interest/awareness/study of climate change and architectural heritage in the Netherlands and France than in other partner countries.

Figure 4.2.1-1 shows an increase in the number of courses since 2017. The reason for this might be that the impact of climate change has become more severe and threatening over the years. An increase in the number of courses coincides with the increasing international policies on climate change. In line with the Paris Agreement and the SDGs, Europe has committed to cutting greenhouse gas emissions and transforming its economy and society in a zero-emission direction. Consequently, capacity building efforts have been undertaken to make the built environment and environmental systems more resilient. Academies and institutes have begun to develop courses addressing issues associated with climate change. For instance, "(Re)Imagining Port Cities: Understanding Space, Society and Culture" course at TU Delft states its objective as to help people make better decisions when addressing challenges port cities face today and when planning for a sustainable and socially just future for port cities in line with the UN SDGs. Another course named "Master Project on Vulnerability", which is a compulsory graduate course offered by TU/e, aims “to develop a critical perspective on vulnerability and adaptation through design to align with governmental spatial adaptation measures on flood areas and SDGs (Goals 6, 11, 13)

The courses vary in terms of their scopes, objectives, target groups, concepts, duration, pedagogical methods, learning environments. CDP research reveals that the majority of the courses are designed by HEIs. Regarding their target groups, the courses can roughly be classified as summer schools, MOOCs, undergraduate and graduate courses. Summer Schools (Table 4.2.1-5) are short-term events that are aimed at a broader audience than students.

Climate heritage and built heritage are largely considered graduate-level topics. We found 28 graduate courses, while there are only two undergraduate courses. (Tables 4.2.1-2-3-4). (toplam 37 ders değil miydi?) Resilience, impact, vulnerability, and adaptation are mostly addressed together [Figure 4.2.1-6]**.** Resilience, vulnerability, and adaptation are the second most frequently grouped terms. Adaptation is the most addressed concept [Figure 4.2.1-7]**.** Vulnerability is most often addressed alongside adaptation.

A lecture-based course involves tutors delivering general principles and fundamental bodies of knowledge that guide and inform students. In studios, the skills and knowledge gained from various domains are applied. It is a "learning-by-doing" method. Students learn by designing. Linking lectures with studios is a useful way for integrating knowledge acquisition and its application. Most studio courses focus on a case study, including fieldwork and workshops to develop adaptation and mitigation strategies. Classes focusing on heritage impact assessment methods, heritage vulnerability, and conservation mostly offer a model of lectures and seminars together.

Most of the in-class courses are instructed by architects and city planners. These courses have limited cooperation with other fields such as engineering, sociology, history, economy, management, environmental and climate sciences. On the other hand, MOOCs are taught by experts with a variety of expertise who often specialize in architecture, urban planning, civil engineering, history, environmental economy, climate change, and social sciences.

When we examined courses according to their focus and extent of dealing with climate change and cultural heritage, two main categories are evident. (Table 4.2.11) First, there are courses offered in built environment related programs (A) and second, there are climate science courses (B).

A. First, there are courses that address climate change and the built environment. These are divided into four sub-categories: A1, A2, A3, A4.

A1 includes a course titled "Construction and Durability." The course is designed for architecture students. The course deals with the sustainability of a variety of construction materials. It discusses both built heritage and climate change in a limited scope.

A2 consists of courses dealing with climate change and the built environment. These courses are offered in Architecture, Civil Engineering, Building and Energy

Technology departments at both the undergraduate and graduate levels. While the broader focus of these courses is on climate change and the built environment, climate change resilient heritage is a small part of them.

A3 comprises courses focussing on built heritage throughout the entire semester/trimester/quarter. One of the topics they discuss is climate resilient heritage as part of a broader discussion. Most of these courses are offered in architecture and urban planning graduate programs. Architects and urban planners teach them, and sometimes engineers, landscape architects, and historians join the team as well. These courses differ in both approach and focus and are thus divided into two subcategories: A3.1, A3.2.

A3.1 contains design courses that provide proposals for adaptations through the transformation of the heritage at various scales, including rehabilitation and retrofitting.

A3.2 includes courses mostly offered by graduate programs of conservation, preservation, or building science. These courses deal with the impact of climate change, vulnerability, and adaptation of built heritage within the context of conservation.

A4 contains courses focused on both climate change and built heritage. The courses focus on climate change and built heritage throughout the semester/ quarter/ trimester. There are three subcategories: A4.1, A4.2, A4.3.

A4.1 includes courses mostly offered by graduate programs of conservation, preservation, or building science. These courses deal with the risk and impact assessment of climate change on built heritage.

A4.2 Courses in this category provide students with a critical perspective on the concept of vulnerability and adaptation through design, in order to adhere to governmental measures on flood areas and the SDGs (Goals 6, 11, 13).

A4.3 contains courses which make heritage assessments and rehabilitation their primary focus, but which also examine multidisciplinary aspects of cultural heritage as a resource for mitigation and adaptation. The graduation project "Resilience and Climate Change" and "Built-up Heritage Over Time" by TU/e, focus on heritage as an asset for climate change mitigation and adaptation fall into this group.

B. Category B courses are mainly concerned with climate science in terms of natural and social sciences. Built heritage is not directly addressed in these courses. Climate change is a phenomenon to be understood through the lens of natural science. Climate change, on the other hand, has complicated causes and implications rooted in historical, social, and economic factors. With a foundation in both natural and social sciences, these courses deal with climate change issues with a focus on cultural geography, history, and sociology, etc.

4.2.2 Games

A comprehensive approach to climate-sensitive and environmentally friendly professional actions can be accomplished through education, enhanced by the use of ICT-based methods. The e-CREHA project aims to design video maze games as one of the innovative learning methods. For this purpose, research was conducted on courses that use games as a complementary tool. Sofiiski Universitet Sveti Kliment Ohridski (SU) made a research particularly on serious games played in Europe through search engines (Google, Bing and Baidu) and Web of Science and Scopus. SU reached the games according to a series of keywords “game(s), mini-game(s), puzzle(s)”, “climate, climate change, environment, environment protection”, “heritage, built heritage, cultural heritage, monuments”, “sustainability, resilience, vulnerability” (See the list of games by years from Table 4.2.2-1).

List of Games		
Title	**Year**	**Country**
Ancient Empires Rome and Egypt	after 2014	Bulgaria
Ancient Pyramids Puzzle	after 2014	Bulgaria
Artifacts Match Game	after 2014	Bulgaria
Bee Simulator	2019	Poland
Beyond Blue	2020	UK
Build a pyramid	2013	UK
Building Climate-Resilient Cities	2019	USA
Change Game	2020	Italy
City Treasure: Mobile Games for Learning Cultural Heritage	2009	Switzerland
Clean and green		UK
Climate Defense		England
Clim’Way'	2008	USA
Endling	2019	Spain
Energy Lab	2021	USA
European Path (e)motion	2019	EC
Free Online Games for Ancient Rome	2010	UK
Geoquiz History Edition		
Great Pyramid of Giza Puzzle	after 2014	Bulgaria

Keep Cool mobil, Multiplier	2016 started (with lots of updates for the following year) 2021-year newest version	Germany
Litter Critters		USA
Mayor's Table	2018	Denmark
Polar Explorer: Sea Level	2020	USA
Polar Lab	2021	USA
Statue Restorer	after 2014	Bulgaria
The Pyramid Adventure		
The Pyramid Maze		
Recycle!		USA
Recycle City!		USA
Recycle Roundup	after 2015	USA
Temtem	2020	Spain
The Seven Wonders of the Ancient World	after 2014	Bulgaria
ThIATRO	2013	Vienna
Trade-off! : Best Coast Belize, ..., Roads to a Resilient Future	2018	USA
Treasure Hunt	2019	Egypt
Turtle Diary's Recycling Waste		USA
Ways2Sort	2018	Denmark
Wonders around the World - Spot the Differences		USA
Climate Hero		

Table 4.2.2-1 List of the games related built heritage and climate change regarding publishing year and country

As a result of this research, 37 games were accessed. In addition, a game (Climate Hero) used in an online course[77] that inspired the e-CREHA project mentioned in the project application text was also included in the research. Thus, 38 games were analyzed in total. [Table 4.2.2-1]

[77] The online course 'ClimAlt' (see https://www.climaltproject.eu/resources/online-course) which is also an Erasmus+ project.

In this research only the games published after 2008 were considered. The first game about climate change (web-based), published in 2008 and titled “Clim‘Way” focuses on energy consumption and new climate conditions while the first game about built heritage was created after a year, in 2009 for mobile usage.

List of Games using for education: engaging built heritage and climate change						
Title	**Game Type**		**Concepts of the game**			
	built heritage game	**climate change game**	**R**	**I**	**V**	**A**
Ancient Empires Rome and Egypt	✓		✓			✓
Ancient Pyramids Puzzle	✓		✓			✓
Artifacts Match Game	✓		✓			✓
Bee Simulator		✓				
Beyond Blue		✓	✓	✓	✓	
Build a pyramid	✓		✓			✓
Building Climate-Resilient Cities		✓	✓	✓	✓	✓
Change Game		✓	✓	✓		✓
City Treasure: Mobile Games for Learning Cultural Heritage	✓		✓			✓
Clean and green		✓		✓		
Climate Defense		✓	✓	✓		
Clim’Way		✓	✓	✓		
Endling		✓	✓	✓		
Energy Lab		✓	✓	✓		
European Path (e)motion	✓		✓			✓
Free Online Games for Ancient Rome	✓		✓			
Geoquiz History Edition	✓					
Great Pyramid of Giza Puzzle	✓		✓			

Keep Cool mobil, Multiplier		✓	✓		✓	✓
Litter Critters		✓		✓		
Mayor’s Table		✓	✓	✓		✓
Polar Explorer: Sea Level		✓	✓	✓		
Polar Lab		✓	✓	✓	✓	
Statue Restorer	✓		✓			
The Pyramid Adventure	✓		✓			
The Pyramid Maze	✓		✓			
Recycle!		✓		✓		
Recycle City!		✓		✓		
Recycle Roundup		✓		✓		
Temtem		✓	✓			
The Seven Wonders of the Ancient World	✓		✓			
ThIATRO	✓		✓			✓
Trade-off!: Best Coast Belize, ..., Roads to a Resilient Future		✓		✓		✓
Treasure Hunt	✓		✓			✓
Turtle Diary's Recycling Waste		✓		✓		
Ways2Sort				✓	✓	
Wonders around the World - Spot the Differences	✓		✓			
Climate Hero		✓				

Table 4.2.2-2 List of the games using for education: engaging built heritage and climate change

The games for education were analyzed to determine whether they covered the concepts of resilience, impact, vulnerability, and adaptation within the framework of built heritage and climate change. According to analysis there are 22 games focusing on climate change while there are 16 games related to built heritage themes [Figure 4.2.2-1]. There is no game where the two fields “built heritage” and “climate change” intersect. In these games the term "resilience" appears prominently [Figure 4.2.2-2]. While the term "adaptation" is

prominent in the built heritage domain, the same term appears less frequently in games focusing on climate change [Table 4.2.2-2].

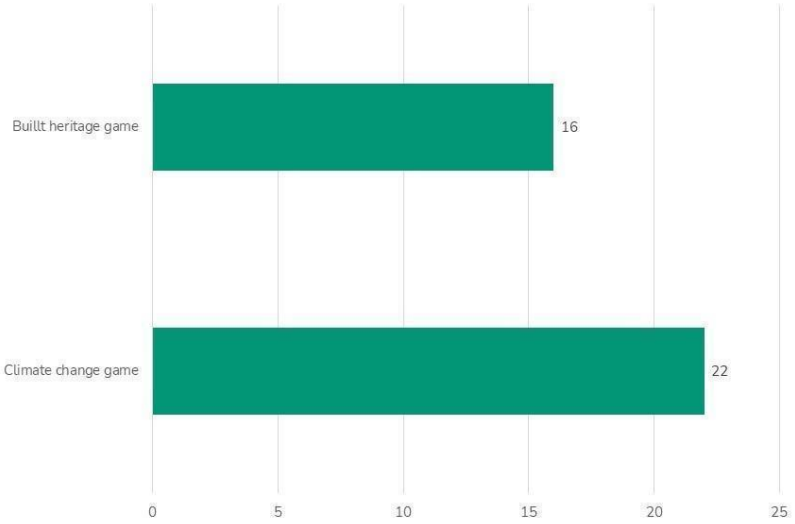

Figure 4.2.2-1 Number of games by fields

There is one game “Building Climate-Resilient Cities” that focuses on all concepts of “resilience”, “impact”, “vulnerability” and “adaptation”. [Table 4.2.2-2].

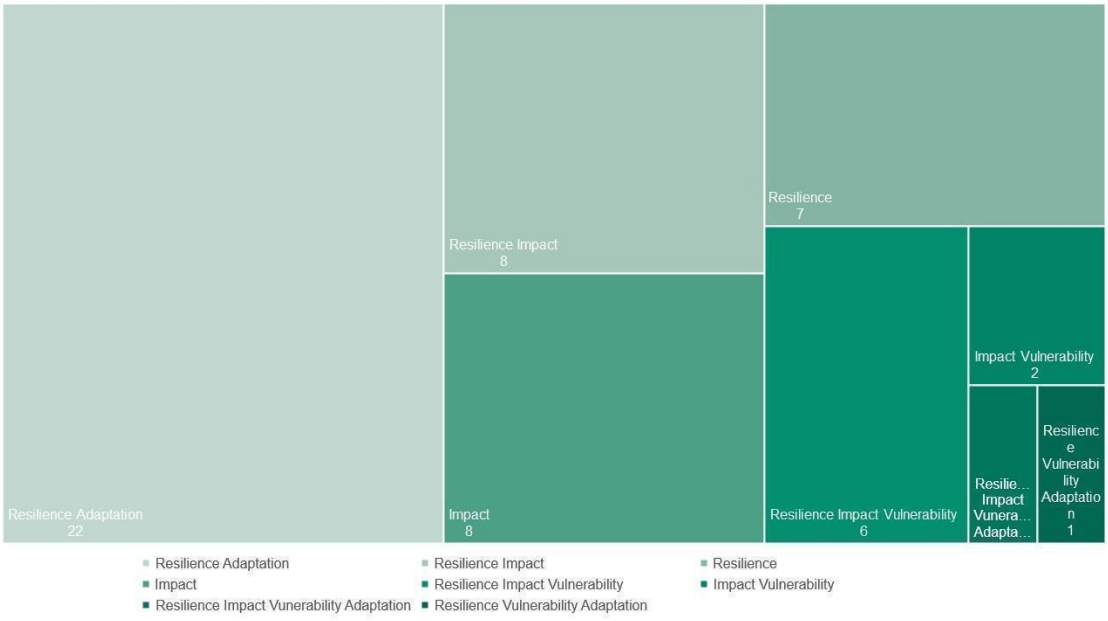

Figure 4.2.2-2 Numbers of games by concepts

Most of the games on built heritage have a variety of environments that include historical places. There are also some games that evaluate the players’ knowledge of art history. The games seem to be made for the younger age group. Regarding climate change, the games

mostly aim to raise awareness of the dangers of such issues as ecology, nature, climate change, recycling, global warming, renewable energy, CO_2 emissions, waste management, rising sea level. While allowing the players to develop solutions to threats, the games also prepare ground for eco-friendly life with nature [Table 4.2.2-3].

Objective and Description of Games related built heritage and climate change		
Title	**Objective**	**Description**
Ancient Empires Rome and Egypt	Sort the artifacts and architecture of Roman and Egyptian empires and find the differences of their culture	Mini-game History Knowledge Board with 10 pictures to sort
Ancient Pyramids Puzzle	The mini-game is part of the Interactive educational tools in cultural heritage - to know ancient pyramid	The Archaeology Knowledge Board includes information and pictures of 8 ancient pyramids, to play with. Part of the Interactive Treasure Hunting educational tools.
Artifacts Match Game	The mini-game is part of the Interactive educational tools in cultural heritage - to memorise12 ancient artifacts	The Archaeology Knowledge Board includes pictures of 12 different ancient artifacts to know and play with.
Bee Simulator	Bee Simulator starts you off as a newly born bee. You're given some tutorials on how to fly and your various bee abilities, and told to go off into the world and collect pollen for the hive. Seems simple enough, but there are factors that are threatening your colony. Explore a world brimming with life in which you collect pollen, defy dangerous wasps and save your hive. Play with others in three game modes, including co-op and PvP on split screen.	They do seem to care about bees, the ecosystem of bees, how important they are to nature, etc. Loading screens tell about the history of honey, bee factoids and the like. You can even dress your bee hero with different bee skins, hats, or have glowing trails as you fly around, purchased with "knowledge points". The music is also pretty pleasant and mellow. The voice acting is somewhat funny, unintentionally so, but not as bad as in some other games. On the whole, it's kind of charming but just doesn't have enough to really support it.
Beyond Blue	The idea is to educate players on how to interact with the ocean in a way that enriches it, as opposed to continuing to destroy it and the countless organic lifeforms to which it is home.	When our game begins, some areas of the ocean are under significant pressure and disruption, while others are showing revitalization following increased global action to mitigate human impact. The world in our fiction is one more attuned to the tie between the health of the ocean and the health of our planet and a growing sense of awe and wonder of the ocean has led to an enthusiasm for exploration of this largely uncharted world, the hope

		of discovery of new life forms here on earth, and the promise of potential insights into medicine, human health, and well-being.
Build a pyramid	To build the pyramid of a pharaoh in a custom way.	The game reveals the process of construction of pyramids.
Building Climate-Resilient Cities	A game to learn about decisions, policies, and overall strategies to improve the climate resilience of a city. You and your fellow players are the leaders—citizens, policymakers, business leaders, nonprofit leaders, and researchers—of a coastal city. You are excited about the potential to make the city a better place, but you are also facing many challenges. One of these is climate change. One impact of climate change is rising sea level, which puts your city at risk of more flooding and of saltwater getting into your soil and freshwater supply. Other effects of climate change in this city include more severe hurricanes, more heat waves, and heavier rainfall in the rainy season. Your job is to make smart decisions that will increase the city's resilience to climate change. The problem? You do not know exactly what impacts climate change will have on your city, how severe they will be, or when they will occur.	Design your own climate-resilient city. Find out: how resilient is your city?
Change Game	Build a city in an urban, rural, mountain, coastal or island environment; Bring in power and water; Build manufacturing and service industries; Manage resources, trade them with other players; Invest in research, education and entertainment; Care for the health, happiness and prosperity of the community.	Play with the planet - Build a city in an urban, rural, mountain, coastal or island environment; Bring in power and water; Build manufacturing and service industries; Manage resources, trade them with other players; Invest in research, education and entertainment; Care for the health, happiness and prosperity of the community.

CityTreasure: Mobile Games for Learning Cultural Heritage	CityTreasure is basically an SMS-based treasure hunt through the streets of Lugano, targeted to school classes from grades 8-12. It capitalizes on the results of an eTourism project, developed in collaboration with the city school district. The challenge of CityTreasure is using mobile technologies for blending curriculum-relevant content into an engaging activity fostering observation, active learning and retention in a powerful informal learning experience.	Groups of students participating in CityTreasure are competing with each other in order to win the game. Different from normal treasure hunts, where the fastest wins, CityTreasure is based on score: the best observers of the city and of its cultural heritage win. CityTresure can be described as a very simple augmented reality team-based city game that supports informal learning.
Clean and green	The game aims to educate children to sort the rubbish lying all around and put it in the right recycling bins. There are 12 objects in the room. Roll over an object to see the name of the object. Click on the object and use your mouse to drag it to the right bin. For example, if the object is made of glass, drag it to the bin marked 'glass'. There are 3 objects in each bin.	In the game, different rubbish is lying all around the room. The waste items are named. The player has to decide which bin to put the items into - Paper, Plastic & Metal, Glass, or Compost.
Climate Defense	A single-player tower defense game that tasks the player with preventing global warming by absorbing carbon dioxide (CO2) before it builds up in the atmosphere.	Climate Defense is a single-player tower defense game that tasks the player with preventing global warming by absorbing carbon dioxide (CO2) before it builds up in the atmosphere. Two modes of play – 1) moulded game-data to make the game enjoyable (easy to win) to play. 2) In the other version the game-data is moulded to better reflect reality; a reality where year after year we pump out more and more CO2. Build towers that represent an amount of trees that will then absorb carbon from emissions of carbon dioxide, thus stopping it from ending up in the atmosphere and adding to the PPM of CO2 already there. Enemy units you need to stop are clouds of CO2

Clim'Way'	Play with Clim'Way® and create your climate plan. Help the community reach the objectives it has set! Will 50 years be enough to reduce greenhouse gas emissions, cut energy consumption and adjust Clim'Way® to new climate conditions?	You will have several objectives in this climate change game. Your main goals will be to reduce greenhouse gas emissions by 75 percent, reduce energy by 40 percent, and increase the production of renewable energy by 60 percent between 2008 and 2058. Every year you will be allocated points that will help you reach these goals. Use Public Authority Points (PA), Enterprise Points (EP), and Citizens Points (PC) in order to carry out actions that reduce greenhouse gas emissions at every turn.
Endling	Will the last mother fox on Earth be able to save its three little cubs? Experience what life would be like in a world ravaged by mankind through the eyes of the last fox on Earth in this eco-conscious adventure. Discover the destructive force of the human race, as it corrupts, pollutes and exploits the most precious and valuable resources of the natural environment's day after day. Explore Endling's 3D side-scrolling world and defend your cubs, three tiny and defenseless fur balls, feed them, watch them grow level after level, notice their unique personalities and fears, and most importantly, help them survive. Use the cover of night to stealthily guide your litter towards a safer place. Spend the day resting in an improvised shelter and plan your next movement carefully since it could be the last for you and your pups.	Experience what life would be like in a world ravaged by mankind through the eyes of the last fox on Earth in this eco-conscious adventure. Discover the destructive force of the human race, as it corrupts, pollutes and exploits the most precious and valuable resources of the natural environment's day after day. Explore Endling's 3D side-scrolling world and defend your cubs, three tiny and defenseless fur balls, feed them, watch them grow level after level, notice their unique personalities and fears, and most importantly, help them survive.
Energy Lab	Investigate what energy is and why some sources are running low while designing renewable energy systems for major cities based on real data models.	Challenge, you'll use scientific data to design renewable energy systems for cities across the U.S.—and compete with others to see whose designs can produce the most power.

European Path (e)motion	Students designed and created a board game that has to do with the European paths about ages 12+. The aim of the game is to involve students in the idea of the path and "meet" it through this pleasant activity. It includes a map of the European paths which each player will cross in order to reach his/her final destination.	
Free Online Games for Ancient Rome	A collection of 28 games and mini games about ancient Rome	
Geoquiz History Edition	A fun and challenging history game for history buffs that works like similar geography games in which you're given the name of a place and have to place a marker on a blank outline map as close as possible to the actual location.	In Geoquiz History Edition you're given the name of a historically significant landmark. The Heritage edition of the game lists historically significant places in the heritage of a country or culture.
Great Pyramid of Giza Puzzle	The mini-game is part of the Interactive Civilization Monuments educational tools. A Serious Heritage Game for History. The player/students have to put together puzzle pieces to form the Giza Pyramid. Observing and learning about history (one of famous world wonders).	Mini-game, History Knowledge, 2D puzzle
Keep Cool mobil, Multiplier	Survive and Prevent climate change by lowering CO2 emissions and temperature and get the most points compared to other players in the game.	You take charge of a city. Build up your economy and earn points! Choice between gameplay: black factories or green technologies. You're a "global player" that tries to advance your own economic interests: Will you choose the path of renewable energy with photovoltaics and wind energy or do you prefer low cost fossil energy sources? When it's your turn you decide whether to collaborate in protecting the climate or do what's best for your own interests.
Litter Critters	The game teaches the basics of recycling. Players sort trash into four different litter categories: recyclables, compost, electronic waste, and landfill waste. In Easy Mode, users sort trash into one category of litter at a time. In Hard	The player is introduced to different bin types, e.g. recycle, compost, electronics, landfill waste and respective types of waste items.

	Mode, users must sort trash into all four categories at once.	
Mayor's Table	Learn about key policy decisions in circular cities. The game is meant for citizens to gain an insight into the complexity of city and waste management. The game can change the player's attitude and behavior with regards to changes made in their city in real life, and thus make them more receptive and accepting towards new waste management initiatives and projects.	Choice-based game - 33 dilemmas regarding waste management. - 4 choices each.(Multiple decisions to be made in each dilemma). You decide which dilemmas to prioritize and what choices to make; dilemmas can expire, and your choices can have great consequences. You have to balance your scores on four different areas: Environment, Technology, Social and Economics. Neglect one, and you may be forced to step down as Mayor.
Polar Explorer: Sea Level	Polar Explorer is an education app. It educates the user about past, present and future sea level. Education is achieved by exploring maps and images created with real data. The user can be guided by text and audio. There are more than 100 topics that can be explored. The user is guided through the app by responding to questions. The app is funded by NSF	I have always been trying to use more data in the classroom and this App delivers exactly that with a guided tour of polar change and how it relates to sea level rise.
Polar Lab	Join top scientists on a quest to discover what the climate of our planet was like in the past and where we might be headed.	Something big is happening to Earth's climate, and the polar regions hold the key to understanding it.
Statue Restorer	The mini-game is part of the Interactive educational tools in cultural heritage - to know popular statues	7 stages with damaged statues that need to be restored by finding the missing element among the 12 pieces of statues provided.
The Pyramid Adventure	The Pyramid Adventure game is an adventure that you play in collaboration with 2 Players. Collect diamonds and solve puzzles in historical pyramids. Complete the sculptures in the pyramid and open the locked doors! Use your weapons for the monsters and traps you encounter. To get out of the pyramid, you have to pass a total of 20 levels. Let the adventure begin!	To explore all the levels of three pyramids and to reach the pharaon room.

The Pyramid Maze	A father and his girl who were wondering inside pyramids, embarked for Egypt. They entered one of the pyramids but then they could not figure out where they needed to go inside of the pyramid. These two adventurers want to explore the inside of pyramids and at the same time they want to collect the diamonds inside of the pyramids. How about embarking on a great adventure with these two adventurers by two players in pyramids?	Two adventurers want to explore the inside of pyramids and at the same time they want to collect the diamonds inside of the pyramids.
Recycle!	An online game that shows students how easy it is to recycle. Students have three minutes to recycle as many items as possible into the plastic, aluminum, and paper containers. See if you can recycle 60 items!	In the game, different waste items are presented to the player. The player has to organize the items into different containers- a metal, plastic or paper recyclable container.
Recycle City!	There's lots to do here - people and places to visit and plenty of ways to explore how the city's residents recycle, reduce, and reuse waste. When you leave this place, you'll know much more about what you can do to help protect the environment.	Explore Recycle City to see how its people reduce waste, use less energy, and save money by doing simple things at home, at work, and in their neighborhoods.
Recycle Roundup	The game aims to educate children to sort the stuff people throw away and put it in the proper bin. Is it recycling, compost, or trash? Help clean up the park! Get facts about climate change and tips on how you can help save the earth.	In the game, different trash items are presented to the player. The player is introduced to different bin types, e.g. recycle, compost, trash, etc., and different items that have to be put in them.

Temtem	According to Ojuel, this influences the game world's emphasis on coexistence and eco-friendliness. However, the world of Temtem is simultaneously on the verge of becoming radically smaller. The recent invention of technology such as airships, which facilitate readily available travel between detached islands, and TemCards, which are Temtem's equivalent of pokéballs, make Archipelago society more universal and easily traversable. As a result, the Airborne Archipelago is a world on the eve of globalization, which nefarious forces such as Clan Belsoto — the game's antagonistic party — seek to exploit, on one occasion even instigating a devastating natural disaster by scientifically rekindling an ancient and sacred volcano.	Temtem's gameplay is largely inspired by the Pokémon series. Players explore the area capturing the eponymous Temtem creatures and command them in battles against other Temtem controlled by an NPC or another player.
The Seven Wonders of the Ancient World	Interactive Civilization Monuments educational tools that include 15 ancient world locations to play with.	mini-game Fly with the saucer and find 7 World Wonders from ancient times. Helps students learn about 7 World Wonders.
ThIATRO	A Serious Heritage Game for Art History. The player/students pass through the museum (3D virtual museum in a real-world exhibition.) observing (experience the exhibition and learning) the 2D exhibitions and perceive learning content that helps learn about art history. Each game level starts with learning content and to advance to the next level the student has to select paintings to fulfill the learning tasks.	Online serious game ThIATRO that immerses the player into an exhibition (3D virtual museum in a real-world exhibition.) and helps students learn about art history. Its playful approach not only increases motivation to learn but also raises interest in art history and cultural heritage in general. It is intended to be used by art teachers as a gentle starting point to communicate the basic concepts of art history.
Trade-off! : Best Coast Belize, ..., Roads to a Resilient Future	A set of mapping games developed by the Natural Capital Project that introduce concepts related to nature's benefits to people, while mirroring analytical approaches with InVEST. Used in Stanford courses and in the Ecosystem Services MOOS (given below). Objectives: To introduce the concept of ecosystem services; To explore tradeoffs across multiple services and between nature's value and development; To demonstrate how spatial data can help inform these decisions; To	Tradeoff! is intended to be played by multiple teams of up to 8-10 people. Each Tradeoff! The version is played in two rounds. During the first round, teams place development pieces (e.g. hotels, farms, port expansions, roads). Between rounds, teams are introduced to the concepts of natural capital and ecosystem services and equipped with additional maps of ecosystem services for their game boards. In the second round, teams then make decisions about replacing

	simulate group and cross-sector collaboration and decision making.	development pieces and adding other conservation pieces to help mitigate the costs of development.
Treasure Hunt	This application is intended to enhance user engagement, increase knowledge about cultural heritage, enhance social interaction between players and ensure an amusing experience for museum visitors. Applied at the Alexandria National Museum in Egypt.	The game is about a thief who tries to steal some treasures from the museum. After he steals the articrafts, he splits them and hides them in the museum. He was caught by the police and during the interrogation he gives some clues about the hidden treasures. The player, who is the policeman, tries to find out which piece of treasure the thief is talking about and where it is hidden in the museum. As the national museum consists of different floors and different periods, it will be a challenge to identify the intended treasure.
Turtle Diary's Recycling Waste	The player has been given three waste bins - Trash bin, Recycle bin, Compost bin and will see various kinds of waste materials. The player has to sort these waste materials by dragging and dropping them into their respective bins.	In the game, different waste items are presented to the player. The waste items are named. The player has to decide which bin to put the items into - recycle, compost or trash.
Ways2Sort	Ways2Sort aims to educate children on the importance of waste sorting and how to sort waste correctly. The game incorporates factual waste sorting data and methods from different municipalities, which makes it highly customizable and relevant for each individual municipality. Target group: Primary, secondary school; Learning objectives: Learn to sort waste properly.	In the game, different waste items are presented to the player, who has to figure out which waste bin to put the items into. The player is introduced to different sorting types, e.g. residual waste, glass, biowaste etc., and different environments, e.g. kitchen, garden and kid’s room.
Wonders around the World - Spot the Differences	The game presents history and illustrations of man-made architectural phenomena, from Machu Picchu to the Great Wall of China. After reading about each location, kids are encouraged to look at side-by-side pictures to spot the differences.	The player explores some of the world’s most spectacular structures. The game provides location and information about 8 world wonders.

Climate Hero	The game is to stimulate youth's constructive outlook towards climate change solutions. The ClimAlt partnership developed a game to raise awareness on the small actions we can take in our everyday lives to reduce our climate and environmental impact 1. Slow down and get back in touch with the world around you. 2. Get creative and rethink what is the true purpose of everyday things. 3. Reduce your energy consumption and save some money on the way. 4. Learn about the food you eat and discover new ways of approaching it	Inside each deck of Climate Hero cards, is inspiration on how you can help combat climate change with simple actions that have a big impact. Grow your own food, reconnect with nature or become an activist

Table 4.2.2-3 Objectives and description of the games related built heritage and climate change

SWOT Analysis

Strengths ● Providing a visual familiarity about place/built environment ● Simulation of the possible climate change scenarios ● Addressing to different age group ● Raising the students' awareness against climate change impacts	**Weaknesses** ● There is only one game pointing out the issue of climate resilient heritage. ● Difficulties about co-working with experts from various disciplines such as architects, software developers, etc. ● Difficulties of updating the game regarding the content of the course
Opportunities ● Online games- easily disseminated through digital platforms (video or digital games) ● Contribution of interactive studying mediums to education	**Threats** ● Impracticality of updating the latest knowledge about the issues ● Probability of players getting wrong information, if it is not prepared in a way that based on scientific truth

Results

When we searched for games in Europe and America, we found a total of 38 games. It is interesting to note that the increase in games, especially in recent years, is in parallel with the increase in policies and plans. It is seen that the issues of "climate change" and "cultural heritage" seem to affect different areas.

One of the earliest games named Clim'way (2008) is an USA produced online game for education purposes that addresses climate change issues touching upon climate change,

energy consumption, global warming etc. and has a broad target population.[78] The earliest example in Europe, is the CityTreasure (2009) is Swiss produced game referring to heritage for tourists, but was adapted to use with schools later on.[79]

The games were produced primarily in the USA, followed by Bulgaria and the UK in Europe. The research included games from the United States that is a developed country in the gaming industry. In this research, 11 out of 38 games were made in the USA. The only game found in our research named “Building Climate-Resilient Cities" that refers to all concepts of “resilience”, “impact”, “vulnerability” and “adaptation” was also a USA produced game. The game addresses climate change which was produced by the National Oceanic and Atmospheric Administration (NOAA)[80].

There is no game addressing both “built heritage” and “climate change”. The issue of climate change was included in the games more than the built environment. Most of the games address climate change focusing on “Resilience”. “Vulnerability” is the least referred theme among the games and it is not being addressed together with the built heritage. The vast majority of games about built heritage make reference to ancient buildings, but especially the Egypt and/or pyramids.

4.2.3 Documentaries

Documentaries based on visual, auditory, and narrative experiences can create a useful learning environment that can influence the audience. In this research the documentaries about climate change and cultural heritage were searched through most popular search engines and the e-CREHA consortium network. In this research, a total of 6 documentaries were examined. The table 4.2.3-1 lists documentaries by year and title.

List of documentaries		
Title	**Name of producing entity**	**Year**
Leiden – Urban planning and heritage	City of Leiden, the Netherlands	2020
Protecting cultural sites against climate change	CYARK / ICOMOS	2020
Heritage at risk: a dialogue on the effects of climate change	SAAM / ICCROM	2020

[78] https://www.cdgr.ucsb.edu/database/game/555
[79] https://museumsandtheweb.com/mw2009/papers/botturi/botturi.html
[80] https://www.noaa.gov

Heritage and resilience. Building a symbiotic relationship	ICCROM	2020
Evaluating the impact of climate change on world heritage sites	UNESCO / ICOMOS	2019
Introduction video watermill landscape / The Watermill landscape and climate change	Molenstichting Noord-Brabant Province of Noord- Brabant De Dommel Water Board Mozaiek Dommelvallei	2021

Table 4.2.3-1 List of documentaries by years

Among the documentaries accessed there are two video seminars and four short videos. Two video seminars are produced by ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property). One short video titled “Protecting cultural sites against climate change”(01m30s) was produced by CYARK/ICOMOS and the other video “Evaluating the impact of climate change on world heritage sites” (03m10s) was made by ICOMOS and UNESCO. (See Tables 4.2.3-1 and 4.2.3-3)

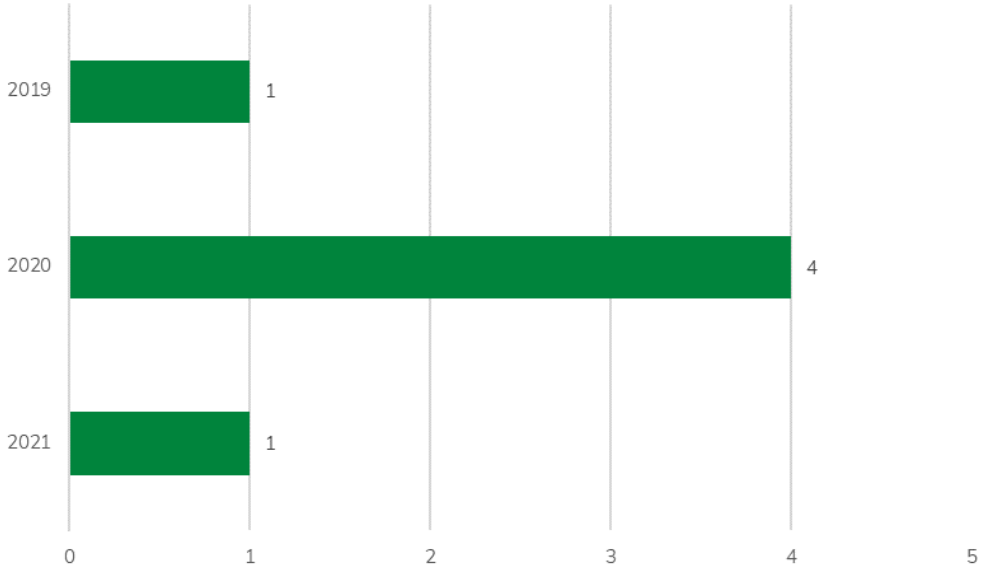

Figure 4.2.3-1 Number of documentaries by year

According to the analysis, it is seen that the first documentaries on the subject started in 2019 with the “Evaluating the impact of climate change on world heritage sites”. The number of documentaries gradually increased in 2020.

Description and impact of documentaries		
Title	**Description of documentary**	**Impact on built heritage**
Leiden – Urban planning and heritage	On urban planning and historical preservation	historical preservation and renewal
Protecting cultural sites against climate change	Clip/teaser leading to websites 5 participants	mainly on historical sites worldwide
Heritage at risk: a dialogue on the effects of climate change	Videostream seminar	mainly on monumental and archeological sites
Heritage and resilience. Building a symbiotic relationship	ICCROM channel	
Evaluating the impact of climate change on world heritage sites	Clip/teaser	mainly on historical and archeological sites
Introduction video watermill landscape / The Watermill landscape and climate change	Watermill Landscapes and Climate Adaptation	historical landscape and industrial heritage preservation

Table 4.2.3-2 Description and impact of documentaries

Half of the documentaries directly refer to heritage and climate change in their titles and address the issues together. One of the documentaries deals specifically with industrial heritage within the concept of heritage.

Broadcasting Media/Platform and duration of documentaries		
Title	**Broadcasting media / platform**	**Duration**
Leiden – Urban planning and heritage	internet	00h05m12s
Protecting cultural sites against climate change	internet Google Arts & Culture	00h01m30s
Heritage at risk: a dialogue on the effects of climate change	internet	01h12m24s
Heritage and resilience. Building a symbiotic relationship	ICCROM channel internet stream meeting	01h03m40s
Evaluating the impact of climate change on world heritage sites	internet	00h03m10s
Introduction video watermill landscape / The Watermill landscape and climate change	the Climate Xtremes and Resilient Heritage workshop / partner's network	00h19m35s

Table 4.2.3-3 Broadcasting Media/platform and duration of documentaries

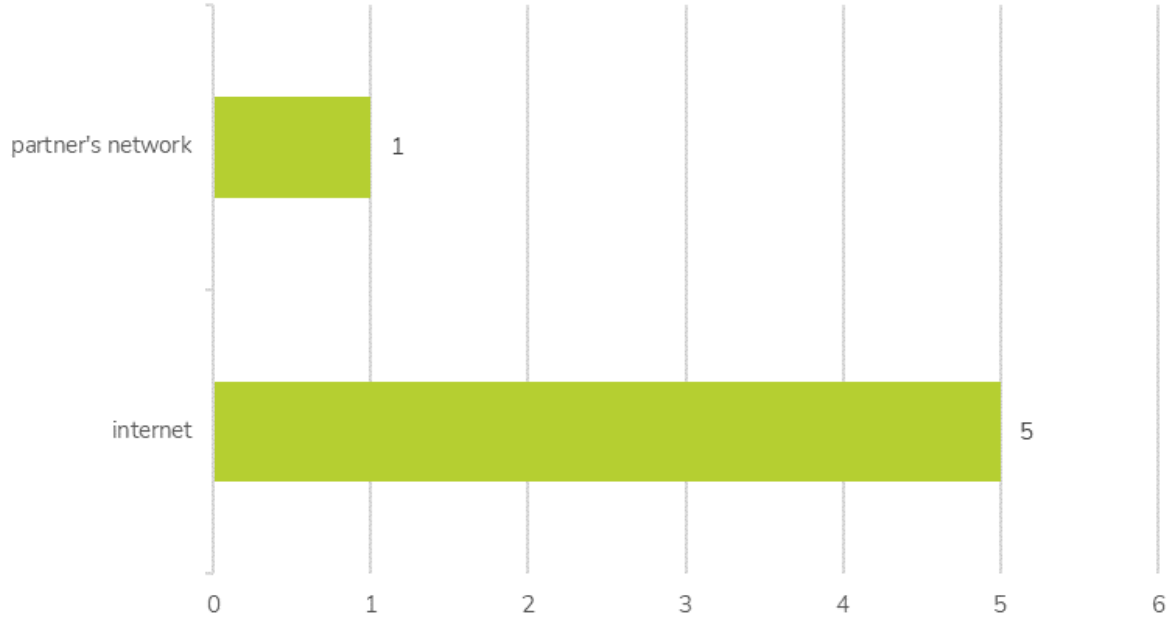

Figure 4.2.3-2 Number of documentaries by B. Media/platform

Almost all of the documentaries in this research can be accessed online. Due to their ease of access, they can reach a large audience.

Producers and concepts (Resilience, Impact, Vulnerability, and Adaptation) of documentaries										
Title	**a higher education institution (HEI)**	**a research institute**	**a commercial company**	**a non-profit organization, association, NGOs**	**a public body at local, regional or national level**	**independent**	**R**	**I**	**V**	**A**
Leiden – Urban planning and heritage					✓					✓
Protecting cultural sites against climate change				✓	✓			✓	✓	

Heritage at risk: a dialogue on the effects of climate change				✓	✓			✓	✓	
Heritage and resilience. Building a symbiotic relationship				✓				✓	✓	
Evaluating the impact of climate change on world heritage sites				✓				✓	✓	
Introduction video watermill landscape / The Watermill landscape and climate change	✓			✓	✓		✓	✓	✓	✓

Table 4.2.3-4 Producers and concepts of documentaries

Figure 4.2.3-3 Number of documentaries by producers

Figure 4.2.3-4 Number of documentaries by concepts

In comparison to "resilience" and "adaptability", "impact" and "vulnerability" are highly discussed concepts in these documentaries.

SWOT Analysis

Strengths • Effective way to raise awareness for climate change problem • Easily accessible and repeatable learning tool/medium	**Weaknesses** • The number of documentaries particularly focusing on climate change and cultural heritage are limited
Opportunities • Easily disseminated through digital platforms.	**Threats** • Budget, film making team, and expertise are required.

Results

In this research, a total of six documentaries were examined. Despite the fact that a number of documentaries present the history of cultural heritage, there is still a lack of documentaries discussing climate change and its impact on cultural heritage. Five of these videos emphasize "vulnerability" and "impact", therefore, it is notable that documentaries tend to put more focus on those two concepts.

The research suggests that non-profit organizations and associations, NGOs and public institutions are more active in producing video documentaries that raise public awareness for climate change and built heritage issues compared to universities and academic research institutes. Among the countries that produced documentaries, it is seen that the Netherlands stands out, and all 2 documentaries were produced by local governance.

4.2.4 Understanding Climate Governance and the Role of Plans and Policies

Planning synergies between climate action and cultural heritage management[81]

In 2015 the Paris Climate Agreement emerged as an almost global commitment to limit global warming to "well below" 2C above pre-industrial levels and to strive to keep temperatures at 1.5C by the end of the century. Together with the UN SDGs, Goal 11, make cities and human settlements inclusive, safe, resilient, and sustainable. In addition, sustainable and Goal 13, taking urgent action to combat climate change and its impacts, require national and local governments to coordinate sustainable climate actions. However, only SDG11 considers "Strengthening efforts to protect and safeguard the world's cultural and natural heritage" among its targets. Whereas the Paris Agreement also aims to strengthen the ability of countries to deal with the impacts of climate change through appropriate financial flows, a new technology framework and an enhanced capacity-building framework. Therefore, implementing SDGs 11 and 13 and their related policy frameworks requires collaborative and coordinated planning mechanisms at the national, regional, and local levels to achieve all targets and considerations for cultural heritage.

The broadly recognized climate emergency has made most governance sectors support climate actions within their remits and responsibilities. However, the inclusion of cultural resources in core national, regional, or municipal climate plans depends on the far-sightedness of each government, to a far greater extent than for other factors of development.[82] Moreover, plans targeting climate action by the cultural sector are starting to emerge in Europe almost five years after the Paris Agreement. For instance, UNESCO is revising its "Policy Document on the Impacts of Climate Change on World Heritage properties", initially drafted in 2007. In Europe, national sectoral plans for cultural heritage are starting to frame climate mitigation and adaptation. However, cultural heritage resources are broad in categories covering different typologies of buildings and land uses that align with other sectoral legal frameworks. For instance, protected buildings for their historical value can include houses, industries, offices, and a broad range of infrastructures placed in urban and rural areas. Thus, depending on the specificities of governance systems, climate actions related to the built cultural heritage are expressed through different planning mechanisms. Therefore, identifying how built heritage is framed as a planning tool for climate actions and understanding how it contributes to the resilience of local communities can be a challenging task. Therefore, future architects must understand how multi-level planning mechanisms for climate action and cultural heritage conservation can

[81] The section was written by Dr. Paloma Guzman (NIKU).

[82] Guzman, P., & Daly, C. (2021). *Cultural Heritage in Climate Planning; The HiCLIP Pilot Project for Understanding the Integration of Culture into Climate Action.* Retrieved from https://climateheritage.org/wp-content/uploads/HiCLIP-FINAL-REPORT-V2.pdf

be enabled as guidelines in the design processes and how these can be navigated to cope with potential conflicts between diverse levels of planning frameworks.

This section describes the importance of climate governance and the role of plans and policies as resources for the inclusion of cultural heritage in local and place-based climate actions. The methodology followed a literature review on planning mechanisms and their implementation patterns for Climate Action and the integration of cultural heritage, focusing on two levels: 1. Literature review to understand state of the art and, 2. The state of the practice in climate planning in the six countries forming the e-CREHA consortium.

Diversity of national planning frameworks for climate action and cultural heritage protection across the e-CREHA consortium

Plans are comprehensive roadmaps used by governments to organize different development concerns such as climate action, urban development, and cultural heritage management covering. Governmental plans aim to define normative visions that state desirable and sustainable futures, the actions to be taken to achieve such futures, and the monitoring systems to assess the progress towards sustainability.[83] Ideally, these governance mechanisms indicate potential and conflicting areas for coordinated actions among public sectors and actors. However, the comprehensiveness, efficiency and complementarity of plans implemented in a geographical location depend on the governance capacities of given localities.[84]

Typically, national-level plans influence the development and implementation of plans at regional and municipal levels. National planning instruments usually determine the public and private sectors with primary responsibilities to drive climate actions. Regional planning typically involves efficiently organizing land-use activities, infrastructure, and settlement growth across a larger land area than an individual city or town. However, cities tend to align themselves to international networks.[85] For instance, the World Heritage Cities Organization and the Covenant of Mayors for climate action are two examples of networks dealing with climate and heritage issues that are particularly relevant for local governments. However, regional plans have a crucial role in understanding how the conservation of cultural heritage contributes to local communities' resilience in the context of a changing climate. In this regard, governance reforms in which decentralization has

[83] Boyle, M., Kay, J., & Pond, B. (2001). Monitoring in support of policy: an adaptive ecosystem approach. *Encyclopedia of Global Environmental Change*, *4*(14), 116–137.
[84] Castán Broto, V. (2017). Urban Governance and the Politics of Climate change. *World Development*, *93*, 1–15. https://doi.org/10.1016/j.worlddev.2016.12.031
[85] Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., De Gregorio-Hurtado, S., … Dawson, R. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production*, *191*, 207–219. https://doi.org/10.1016/j.jclepro.2018.03.220

delegated responsibilities for decision-making to local governments are particularly relevant.[86]

This section demonstrates the different ways and patterns in which climate actions and cultural heritage protection are organized in the six countries represented in the e-CREHA consortium. The other available climate action plans and heritage legal frameworks in the six European countries represented in the e-CREHA consortium show different dates of elaboration (Table 4.2.4-1). For example, climate plans have been implemented in the last three years, whereas most heritage acts date from before the Paris Agreement. Thus, these have no considerations for climate action. However, not all climate plans explicitly include cultural heritage. When they do, actions tend to 1) recall cultural heritage laws, 2) request climate impact assessments on cultural heritage, 3) delegate to local levels planning climate actions for all sectors in the built environment, including cultural heritage. Therefore, local planning practices are essential to understand in the relationship with national planning frameworks.

Country	National Climate Action Plan/ Year	Inclusion of Cultural Heritage	Heritage legal framework / Year	Inclusion of CA
Bulgaria	Integrated Energy and Climate Plan of The Republic of Bulgaria / 2021	No	Cultural Heritage Act / 2009	No
	National Climate Change Adaptation Strategy and Action Plan / 2019	Potential negative impacts by sector: Tourisms: Cultural and heritage site threatened by fire, floods, and so on		
France	National Low-Carbon Strategy / 2020	Building renovation and construction actions, pay particular attention to the impacts on air quality, the consumption of resources, biodiversity, waste and the preservation of landscape and architectural heritage. All these parameters will be evaluated during impact studies.	Heritage Code / 2004	
	2nd National Climate Change Adaptation Plan / 2017	The Ministry of Culture, museum curators and public cultural cooperation institutions will work to integrate the impacts of climate change into management plans for cultural heritage assets and into actions for the preservation of cultural heritage and will ensure that the safeguarding plans for cultural property be adapted to foreseeable climatic hazards in the medium and long terms (Action P & R-7).	LAW No. 2016-925 on the freedom of creation, architecture and heritage / 2016	No

[86] Loeffler, E., & Bovaird, T. (2017). From participation to co-production: Widening and deepening the contributions of citizens to public services and outcomes. In *The Palgrave Handbook of Public Administration and Management in Europe* (pp. 403–423). https://doi.org/10.1057/978-1-137-55269-3_21

Italy	Integrated National Energy and Climate Plan / 2019	the Budget Law for 2020 assigns the local authorities' allocations, subject to cost reporting, to cover the definitive planning and execution of measures to ensure the safety of areas at hydrogeological risk, to improve safety and energy efficiency in schools, public buildings, and municipal heritage and to ensure the safety of roads of up to €85 million for 2020, €128 million for 2021, €170 million for 2022 and €200 million for each of the years from 2023 to 2034.	Code of the Cultural and Landscape Heritage / 2004	No
	National Adaptation Strategy to Climate changes / 2021	Transversal line as 3.14. Critical Infrastructure. Non-structural or "soft" actions: 26 actions across three themes: Built heritage, landscape and Materials exhibited in a museum environment		
Netherlands	National Climate Agreement (Mitigation) / 2019	No	Heritage Act / 2016 Spatial Planning Act / 2007	No No
	Integrated National Energy and Climate Plan (Mitigation) / 2019	No		
	Delta Programme (Adaptation) / 2021	3.5.1 Implementation programmes; 5.5.2 Conducting risk dialogues and drawing up strategies;		
Turkey	Turkey's National Climate Change Adaptation Strategy and Action Plan (Draft) / 2021	UO1.1.5. Preparing regional strategies for natural and cultural heritage areas with regards to adaptation to climate change	Law on the Conservation of Cultural and Natural Property (2863)	No
Norway	Climate Change Act / 2017	No	Cultural Heritage Act	No
	The Planning and Building Act	(a) establish goals for the physical, environmental, economic, social and cultural development of municipalities and regions, identify social needs and functions, and state how these functions can be discharged (b) safeguard land resources, landscape qualities and the conservation of valuable landscapes and cultural environments (c) protect the natural basis for Sami culture, economic activity and social life.	New goals for Norway's cultural environment policy	Mitigation and Adaptations considerations

Table 4.2.4-1 National legal frameworks on climate action (CA) and Cultural Heritage in e-CREHA countries

Local planning patterns for climate action and cultural heritage protection across the e-CREHA consortium

There are different patterns in which climate planning is organized locally in the six countries forming the e-CREHA consortium. An assessment study by Reckien et al.(2018) of local climate plans in 885 cities in the EU-28 state parties is helpful to understand how climate action can be found in two main planning formats. 1) as stand-alone thematic plans for mitigation and adaptation; and 2) mainstreamed as a sub-theme within other sectoral plans (health, natural resource management, cultural heritage management etc.). The study by Reckien et al.(2018) showed that by 2017, European national and local governments had prioritized mitigation over adaptation. This has been attributed to economic incentives and savings for and of improved energy security and emission reductions. At the same time, adaptation is seldomly carried out systematically across sectors. Also, there is a significant disparity in the existence of local climate plans across European countries. A closer look into the cities from the e-CREHA European countries (see Table 4.2.4-2), showed that cities in France and the Netherlands are more likely to have a climate action plan. In contrast, Italian and Bulgarian towns tend to have a lack. Moreover, the governance context in which cities develop their plan also changes from country to country. For instance, since 2010, the national government has made local climate plans compulsory in France. According to Reckien et al.(2018), this mandate led to more thematically narrow and technical climate plans. In the Netherlands, local climate action tends to be included in broader sustainability plans. Furthermore, multi-level interaction occurs according to different spatial planning systems. This is particularly salient in the Netherlands and Italy, where water management plans are essential in adaptation actions and usually cover larger territorial areas. Moreover, a few Bulgarian cities (5) are in the EU-28 signatory to the Covenant of Mayors, thus, committing to developing a Sustainable Energy Action Plan (combining mitigation and adaptation) under the auspices of international climate networks. Other ways in which cities may organize their climate action include broader sustainability and other development plans. However, the report by Reckien et al.(2018) synthesized did not revise these plans.

Country	Cities Audited	Mitigation Plans	Adaptation Plans	Joint Plans	No plans
Bulgaria	18	-	-	5	13
France	98	74	54	53	24
Italy	76	-	2	-	74
Netherlands	51	15	1	-	35

Table 4.2.4-2 Number of mitigation, adaptation and joint plans in countries where LCPs are compulsory or autonomous adapted by Reckien et al.(2018)

Other ways in which cultural heritage is included in climate actions correspond to the references to its intangible assets as part of benefits from landscapes, ecosystems and the relationships with places and sites. Cultural values, sense of place, and identity are among the characteristics that are recognized as important links between societies and the natural

environment and their importance to adapt to climate change.[87] Such references come from sectors such as agriculture and natural resource management. Therefore, developing skills to navigate and understanding how collaborative and efficient governance mechanisms (such as legal, operational, and monitoring frameworks) can advance or refrain urban and architectural project design is essential in current and future undergraduate and graduate education. Understanding how practices for cultural heritage conservation correspond to governance organizations and answer to policy goals will provide future heritage practitioners to better respond to different practical scenarios and imagine different ways for interdisciplinary and intersectoral cooperation.

[87] Guzman, P., & Daly, C. (2021). *Cultural Heritage in Climate Planning; The HiCLIP Pilot Project for Understanding the Integration of Culture into Climate Action.* Retrieved from https://climateheritage.org/wp-content/uploads/HiCLIP-FINAL-REPORT-V2.pdf

5. CONCLUSION

The report “Cross-disciplinary Pedagogies” (CDP) is the first intellectual output of the e-CREHA project. CDP is based on research & analysis to understand the state of the art on the critical question of how heritage education addresses climate change. Therefore, the report aims at identifying current pedagogical approaches/tools taking into account courses, games, use of media outputs/documentaries and relevant climate plans and policies. In this research, a template was prepared in an excel file and many questions of different categories were asked to be searched and answered by the e-CREHA partners. A convenient sampling based on geographic specialization was applied including the methods/tools adopted in consortium countries starting from their home countries which are most accessible to the partners. This is an efficient way to gather data from Europe and also beneficial for specifying local approaches by means of partners’ networks.

The results of the **courses** reveal that heritage education addresses climate change issues in several ways. For instance, the Dutch HEIs study this issue in 4 groups; Technology-Science Schools, Nature-Science Schools, Practice Based Schools, and Humanities Related Schools. All these programs have different methods and objectives. While some of those have a clear focus on mitigation through nature based solutions, some others study in the scope of heritage studies. This situation clearly shows that heritage and climate change is not yet considered as a specialized education. In addition, the programs are limited to graduate students with specialized skills and interests. The “adaptation” is the leading concept among the other concepts in the courses.

The CDP report also includes research & analysis of how heritage education in relation to climate change integrates **serious games.** The courses are not planned as part of the courses. None of the games address both “built heritage” and “climate change” issues. There are more games on climate change than on the built environment. While most of the games addressing climate change focus on “resilience”, the least referred concept is the “vulnerability”. It is not being addressed together with the built heritage.

The CDP report contains research & analysis of the **documentaries** referring to cultural heritage and climate change. Among the documentaries accessed there are two video seminars and four short videos. Despite the fact that a number of documentaries present the history of cultural heritage, there is still a lack of documentaries discussing climate change and its impact on cultural heritage. Half of the documentaries directly refer to heritage and climate change in their titles and address the issues together. 1 of the documentaries deal specifically with industrial heritage within the concept of heritage.

According to the analysis in 3 categories (courses/games/documentaries), it is seen that the concept of “adaptation” is most prominent in courses, “resilience” takes the majority in games, whereas “impact” and “vulnerability” together are the most addressed concepts in documentaries. It is observed that there is no coherent tendency in this regard among the categories.

Another quality that made the CDP report valuable was that the issue was handled holistically with all actors and perspectives. This study briefly mapped the existing climate strategies and actions in Europe and tried to determine how these issues were considered in Europe by revealing the national/regional/municipal approaches of the countries on this issue. The report indicates important gaps between climate actions and cultural heritage objectives that both as part of multi-level planning mechanisms need to be corresponded by means of common targets and new approaches. P. Guzman from NIKU, partner of e-CREHA, by referring to policies listed her suggestions to overcome these dichotomies by proposing maximization of engagement between those dualities and developing different practical scenarios and new ways based on interdisciplinary and intersectoral cooperation. Developing a new curriculum, opening new dimensions in the education, training of future practitioners mastering climate change planning and cultural heritage management recognizing local contexts are the highlighted points.

The analysis reveals that there is a greater interest/awareness/study of climate change and cultural heritage conservation in the Netherlands and France than in other partner countries. Similarly, it is seen that the documentaries made by local authorities in the Netherlands lead the list. The results of climate policies show that cities in France and the Netherlands are more likely to have a climate action plan.

It is important to note that there were some limitations in the research process. Research through the internet is a practical way providing strong advantages of rapidly collecting a diverse and large-scale data. To mention the limitations in data collection, accessing information about educational programs, games, documentaries, and climate plans and policy was not easy if searched data was not accessible on the internet. Some specialized online platforms like the European Climate Adaptation Platform online (Climate-ADAPT) to search plans & policies and online learning platforms like Coursera to search the MOOCs were quite useful for providing systemized data on this search. Yet, in the absence of a database on a specific field accessible for researchers or in case of searching the data through online search engines with wrong keywords, searched data may not be found which might affect the results. Apart from these, Mavromatidis highlighted some of the limitations on dissemination of existing works such as the lack of information about educational programs on the websites, challenges in dissemination of the pedagogical results of training courses, unfrequency of student publications, lack of a reliable policy for

archiving results in school libraries and the fact is that the opportunities for sharing ideas among instructors are often limited to workshops and Final Diploma Project juries only. B. Bontchev from SU, another partner of the e-CREHA project, similarly touched upon some limitations on data collection by saying that even though some games matching the keywords were found, those were in fact unavailable for some reasons (Flash-based games or their host site had expired or was inaccessible) so that were not taken into account in this research.

Another limitation observed in this research in the phase of data collection was the language barrier. Knowing many languages was an opportunity for partners to search the data in different languages. English, Dutch, French, German, Spanish, Portuguese, Swedish, Norwegian, Bulgarian and Turkish are some of the languages searched, yet it is thought that searching in some certain languages might have created a barrier to accessing information. Similarly, Bontchev referring to games search on the internet asserted that the search queries made by the project partners in languages, such as English, Spanish, Italian and Bulgarian provide limited data, yet for a more comprehensive study, search queries should be created in Russian, Turkish, Dutch, German, French and other languages.

Qualitative analysis provides identifying key problems, methods, conceptualization and practice that puts forth more precise results in social realities. But, it should also be noted that there are some limitations when analyzing the data. In this report, the analysis was based on data available to assess. However, in some cases the nature of the data may not be very descriptive. For example, the courses engaging the terms resilience or vulnerability can create meaningful patterns and connections to analyze in terms of revealing how they approach the issue, however it may not be enough to create relevant conclusions if the method or content of the course were not clearly described.

In spite of several limitations, remarkable results were attained in this report. The report can be assessed as an accumulation of a big pile of knowledge obtained from a variety of teaching, learning and training environments. Moreover, it can be regarded as a source that shows the current pedagogies and methods on resilient climate heritage and the steps (pedagogical and practical) to be taken today in those environments. All those studies conducted on identification of approaches in architectural education are highly beneficial in allowing the results to be assessed in this report and disseminated later in other platforms. In that sense, collaborative work offered great advantages. It was also a great advantage while collecting data, the template has been updated when necessary, upon recommendations of the partners from different disciplines/approaches and finalized as a result of cooperative study. This offered a great opportunity to find the questions for the survey that need to be researched together.

Impacts of CDP

The project report has a very important contribution to the literature. The report can be regarded as an exemplary source that may have several impacts in future, regardless of time related, geographical and economic limitations:

- It may be used as a basis for a variety of research/study
- It may lead to discovery of different innovative tools
- It may encourage updates on educational models
- It may lead to development of new game design presenting effective impacts on education
- It may encourage production of more visual materials which is easy to distribute that helps raising awareness in other geographies
- It may lead to adoption of climate related courses in different fields
- It may create fruitful platform for discussion of the relationship between teaching activities and adapting the climate plans and policies
- It may create opportunities to discover new methods of cooperation, detect the problems and take action
- It may be introductive and encouraging for other geographies to have more focus on climate change issues and to initiate similar studies
- It may lead to emergence of a global cooperation in education, revealing that global cooperation is not only limited to policies.

To conclude, the results signify the lack of platforms to discuss the diverse levels of planning, cultural heritage conservation and climate actions, which should be considered together to guarantee vulnerable environments. It is noteworthy to claim that mostly the cultural heritage conservation and climate change actions are not considered together. This led to emergence of interdisciplinary gaps between climate change and cultural heritage, teaching activities and their adaptation of policies of different levels to local capacity building. The report stresses corresponding of those by means of common targets and new approaches and suggests interconnection between educational methods and professional needs. There is a need for developing a multi-disciplinary approach to engage with these multi-level planning mechanisms. Therefore, urban and architectural project design is essential in current and future undergraduate and graduate education. The future practitioners /policy makers/designers will be better trained and qualified to apply traditional construction techniques, cultural meanings and implications, and innovative technological approaches in adaptation. CDP attempts to fill this gap by mapping the current pedagogical tools/methods identifying the problems and needs of teaching, learning and training environments, and gaps between various actors involved in different scales and contributing to the development of new approaches for better learning achievements.

REFERENCES

Abdul Jabbar, A.I. and Felicia, P. «Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review.» *Review of Educational Research 85, no. 4*, 2015: 740-779.

ACE. "20 Architectural Projects Against Climate Change." 2018. https://www.ace-cae.eu/fileadmin/New_Upload/7._Publications/Others/2018/ACE_CHANGEMENTS_CLIMATIQUES_A5_HORIZ_2018_WEB.pdf (accessed November 5, 2021)

ACE. 2021. "A Sustainable, Fair and Beautiful Built Environment to Address the Climate and Biodiversity Crisis." Statement presented at "Climate Change & Built Heritage" Conference, on the occasion of the ACE, Brussels, October 28, 2021. .https://www.ace-cae.eu/fileadmin/user_upload/ACE_CC_CONF_DRAFT_STATEMENT.pdf (accessed November 5, 2021,)

Adapt Northern Heritage (2017-2020). *Adaptation stories: Examples of risk assessment, adaptation planning and conservation management of northern historic places.* 2020. https://niku.brage.unit.no/niku-xmlui/bitstream/handle/11250/2736543/AdaptNorthernHeritage_AdaptationStories.pdf?sequence=2&isAllowed=y (accessed November 5, 2021)

Alessandro De Gloria, Francesco Bellotti, ve Riccardo Berta. «Serious Games for education and training.» *International Journal of Serious Games, 1(1) (january)*, 2014. doi:10.17083/ijsg.v1i1.11

Asensio, Mieria, ve Clive Young. «A learning and teaching perspective.» In *Click and go video: Video Streaming—A guide for educational development*, edited by Sally Thornhill, Mieria Asensio Ve Clive Young, 10-19. Manchester: The JISC Click and Go Video Project, 2002. http://www.ClickandGoVideo.ac.uk (accessed November 5, 2021)

Boccardi, Giovanni. "From Mitigation to Adaptation: A New Heritage Paradigm for the Anthropocene." In *Perceptions of Sustainability in Heritage Studies*, edited by Albert, Marie-Theres, Berlin: De Gruyter. 2015:87–97.

Boyle, Michelle, James J. Kay, ve Bruce Pond. «Monitoring In Support Of Policy: An Adaptive Ecosystem Approach.» *Encyclopedia of Global Environmental Change 4(14)*, 2001: 116-137. http://documentacion.ideam.gov.co/openbiblio/bvirtual/017931/DocumentosIndicadores/Temasvarios/Docum8.pdf (accessed november 7, 2021)

Brown, Katrina. *Resilience, Development and Global Change*. London: Routledge. 2016.

Carneiro, Roberto. «Open Educational Practices and Generativism.» 2010. http://cloudworks.ac.uk/cloud/view/3827 ; (accessed November 10, 2021).

Cassar, May & Pender, Robyn. The impact of climate change on cultural heritage: Evidence and response. In *Proceedings of the ICOM Committee for Conservation: 14th Triennial Meeting*, The Hague, The Netherlands, 12–16 September, 2005. 610–616.

Castán Broto, Vanesa. «Urban Governance and the Politics of Climate Change.» *World Development 93 (February)*, 2017: 1-15, doi:10.1016/j.worlddev.2016.12.031.

Ceccarelli, Paolo. "Past Is Not a Frozen Concept: Considerations about Heritage Conservation in a Fast Changing World", *Built Heritage* 1, no. 3, 2017: 1–12.

Climate ADAPT. (n.d.). EU Adaptation Strategy.
https://climate-adapt.eea.europa.eu/eu-adaptation-policy/strategy (accessed November 10, 2021).

Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. , 32, *World Meteorological Organization, Geneva, Switzerland,* 2018. . www.ipcc.ch/sr15. (accessed November 5, 2021)

Cultural Heritage Agency of the Netherlands. "Act of 9 December 2015, comprising an inventory and adaptation of regulations pertaining to cultural heritage', or 'the Heritage Act'". 2016, (English translation.)
https://english.cultureelerfgoed.nl/publications/publications/2016/01/01/heritage-act-2016
(accessed November 6, 2021)

DeSilvey, Caitlin. *Curated Decay. Heritage Beyond Saving*. Minneapolis: University of Minnesota Press. 2017.

Domínguez, Adrián, Joseba Saenz-de-Navarrete, Luis de-Marcos, Luis Fernández-Sanz, Carmen Pagés, ve José-Javier Martínez-Herráiz. «Gamifying learning experiences: Practical implications and outcomes.» *Computers & Education 63, (April*, 2013): 380-392, doi: 10.1016/j.compedu.2012.12.020

Douglas, Mary and Wildavsky, Aaron. *Risk and Culture*. Berkeley: University of California Press. 1982.

Elizabeth Brooks, Abid Mehmood, Simin Davoudi,"Evolutionary Resilience and Strategies for Climate Adaptation," Planning, Practice & Research, 28(3), 2013:307–322, doi: 10.1080/02697459.2013.787695

Eriksen, Thomas Hylland. "Between Universalism and Relativism: A Critique of the UNESCO Concept of Culture." In *Culture and Rights. Anthropological Perspectives*, edited by J. K. Cowan, M.-B. Dembour and R. A. Wilson, 127–148. Cambridge: Cambridge University Press. 2001.

EU. Directive 2013/55/EU of the European Parliament and of the Council. Official Journal of the European Union, (2013): 132–170.
https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0132:0170:en:PDF

EU. "New European Bauhaus." 2021.
https://europa.eu/new-european-bauhaus/delivery_en (accessed November 10, 2021)

European Commission, "Press statement by President von der Leyen on the New European Bauhaus," Brussels, 2020.
https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_20_1902. (accessed 14 October 2020.)

Europa Nostra. Cultural Heritage as an integral dimension of the " New European Bauhaus " initiative. supra note 39. 2020.
https://www.europanostra.org/wp-content/uploads/2020/12/202012-New-European-Bauhaus_Europa-Nostra-Statement.pdf (accessed November 8, 2021)

Field, C. B., V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, et al., eds. "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation". *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.2012.

Folke , Carl , Stephen R. Carpenter , Brian Walker, Marten Scheffer, Terry Chapin , ve Johan Rockström. «Resilience Thinking: Integrating Resilience, Adaptability and Transformability.» *Ecology and Society 15,* no. 4*: 20*, 2010. http://www.ecologyandsociety.org/vol15/ iss4/art20/ (accessed November 8, 2021)

Gunderson, Lance H., Holling, C.S. and Light, Stephen S.. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York: Columbia University Press. 1995.

Gunderson, Lance H. and Holling, C.S. *Panarchy: Understanding Transformations in Human and Natural Systems* .Island Press. 2002.

Gunderson, Lance H., Allen, Craig Reece and Holling, C. S. *Foundations of ecological resilience*. New York:Island Press, USA. 2010.

Guzman, Paloma and Daly, Cathy. *Cultural Heritage in Climate Planning; The HiCLIP Pilot Project for Understanding the Integration of Culture into Climate Action,* 2021. https://climateheritage.org/wp-content/uploads/HiCLIP-FINAL-REPORT-V2.pdf (accessed November 8, 2021)

Hambrecht, George and Rockman, Marcy. "International approaches to climate change and cultural heritage," *American Antiquity* 82, no. 4, 2017: 627–641, doi: 10.1017/aaq.2017.30

Harrison, Rodney. *Heritage. Critical Approaches.* London: Routledge. 2013.

Harvey, David C., and Perry, Jim. "Heritage and Climate Change: The Future Is Not the Past." In *The Future of Heritage as Climates Change. Loss Adaptation and Creativity*, edited by David C. Harvey and Jim Perry, 3–21. London: Routledge. 2015.

Holtorf, Cornelius. "Embracing change: how cultural resilience is increased through cultural heritage," *World Archaeology* 50, no. 3, 2018:1-12, doi: 10.1080/00438243.2018.1510340

Howard, A. J., Challis, K., Holden, J., Kincey, M., & Passmore, D. G. (2008). The impact of climate change on archaeological resources in Britain: A catchment scale assessment. *Climatic Change*, 91(3–4), 405–422. https://doi.org/10.1007/s10584-008-9426-9.

ICCROM. "A Guide to Risk Management of Cultural Heritage." 2016. (accessed November 7, 2021) https://www.iccrom.org/wp-content/uploads/Guide-to-Risk-Managment_English.pdf

ICOMOS. "ICOMOS Work on Climate Change." 2019. (accessed November 7, 2021) https://www.icomos.org/en/focus/climate-change/60669-icomos-work-on-climate-change

ICOMOS Climate Change and Heritage Working Group. "The future of our pasts: Engaging cultural heritage in climate action." *Outline of Climate Change and Cultural Heritage*. 2019. (accessed November 7, 2021)
https://indd.adobe.com/view/a9a551e3-3b23-4127-99fd-a7a80d91a29e

Inayatullah, Sohail. «Anticipatory action learning: Theory and practice.» *Futures* 38, no. 6 (August 2006): 656-666.

IPCC (Intergovernmental Panel on Climate Change). "Climate Change 2007: Synthesis Report." Contribution of Working Groups i, ii and iii to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; IPCC: Geneva, Switzerland, 2007: 104.

IPCC, “Annex I: Glossary” [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press, 2018.

IPCC, “Annex I: Glossary”, edited by Matthews, J.B.R. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, edited by Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield, Cambridge University Press, Cambridge, UK and New York, NY, USA, 2018: 541-562, doi:10.1017/9781009157940.008.

IPCC, “Summary for Policymakers”. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. https://www.ipcc.ch/sr15/chapter/spm/ (accessed November 5, 2021)

IPCC, *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou. Cambridge University Press, 2021. In Press. www.ipcc.ch/report/sixth-assessment-report-working-group-i. (accessed November 5, 2021)

Jigyasu, Rohit. “Reducing Disaster Risks to Urban Cultural Heritage: Challenges and Opportunities.” In *Hriday Reflections: A Monograph on Heritage City Development and Augmentation*, edited by Jigna Desai, Gurmeet Sangha Rai, and K. T. Ravindran 65–72. Delhi: CEPT University and ICOMOS India. 2017.

Kabisch, Nadja; Korn, Horst; Stadler, Jutta; Bonn, Aletta. *Nature-based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*. Springer. 2017.

Karner, Franz-Werner and Gottfried Hartel. «Theory and Taxonomies of Serious Games.» ENTRExplorer, 2010. 2010-1-PT1-LEO05-05190 Correlation (entrexplorer.com)

Karppinen, Paivi. “Meaningful learning with digital and online videos: Theoretical perspectives.” *AACE Journa*l 13, no. 3, 2005:233-250.

Kolb, David. *Experiential Learning. Experience as the Source of Learning and Development*, New Jersey: Pearson Education, 2015.

Korkut, Şafak, Dornberger, Rolf, Prajakta, Diwanji, Puthur Simon, Bindu and Märki, Michael. “Success Factors of Online Learning Videos” , International Journal of Interactive Mobile Technologies 9, no. 4, 2015: 17-22. doi: 10.3991/ijim.v9i4.4460

Lance H. Gunderson and C.S. Holling. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, 2002.

Liu, S. “Environmental Education through Documentaries: Assessing Learning Outcomes of a General Environmental Studies Course” *Eurasia Journal of Mathematics, Science and Technology Education* 1484. 2018:1371-1381. doi: 10.29333/ejmste/83653

Loeffler, Elke and Tony Bovaird. «From Participation to Co-production: Widening and Deepening the Contributions of Citizens to Public Services and Outcomes.» In: *The Palgrave Handbook of Public Administration and Management in Europe*, edited by Edoardo Ongaro ve Sandra Van Thiel, 403–423. London: Palgrave Macmillan, 2017. doi: 10.1057/978-1-137-55269-3_21

Ministère de la Transition Ecologique, République Francaise. “le Plan national d’adaptation au changement climatique.” 2018. https://www.ecologie.gouv.fr/sites/default/files/2018.12.20_PNACC2.pdf (accessed November 6, 2021)

Ministere de Transition Écologique et Solidaire, France. “Strategie Nacionale Bas-Carbone” https://www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf (accessed November 6, 2021)

Ministero dell’Ambiente e della Tutela del Territorio e del Mare. “Strategia Nazionale di Adattamento ai Cambiamenti Climatici.” 2021. https://pdc.minambiente.it/sites/default/files/allegati/Strategia_nazionale_adattamento_cambiamenti_climatici.pdf (accessed November 6, 2021)

Ministry of Economic Affairs and Climate Policy, The Netherlands. “Climate Agreement.” 2019. https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands (accessed November 6, 2021)

Ministry of Economic Affairs and Climate Policy, The Netherlands. “Integrated National Energy and Climate Plan 2021-2030.”. 2021. https://ec.europa.eu/energy/sites/ener/files/documents/nl_final_necp_main_en.pdf (accessed November 6, 2021)

Ministry of Economic Development, Italy. “Integrated National Energy and Climate PLAN.” 2019. https://ec.europa.eu/energy/sites/default/files/documents/it_final_necp_main_en.pdf (accessed November 6, 2021)

NEBC, “Statement:Making the Renovation Wave a Cultural Project”, 2020. NEBC statement.docx (ace-cae.eu) (accessed November 5, 2021)

Noah’s Ark . Global Climate Change Impact on Built Heritage and Cultural Landscapes (Noah’S Ark). (2011). https://cordis.europa.eu/project/id/501837/reporting (accessed November 5, 2021)

Papastergiou, M. “Digital Game-Based Learning in high school Computer Science education: Impact on effectiveness and student motivation.” *Computer and Education* 52, 2009:1-12. doi: 10.1016/j.compedeu.2008.06.004

Potts, A (Lead Author). European Cultural Heritage Green Paper. Europa Nostra, The Hague & Brussels, 2021.

Press Release. “ICOMOS releases “Future of Our Pasts” report to increase engagement of cultural heritage in climate action”. 2019.
Outline_Press_Release_FINAL.docx (live.com) (accessed November 6, 2021)

Qian Wang, Maskazu Yamashita, “Social-Ecological Evolutionary Resilience: A proposal to Enhance “Sustainability Transformation” about Theoretical Foundation”, Open Access Library Journal 2, no.3, 2015:1-8. doi: 10.4236/oalib.1101426.

Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., De Gregorio-Hurtado, S., … Dawson, R. “How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28.” *Journal of Cleaner Production*, *191*, 2018: 207–219. doi: 10.1016/j.jclepro.2018.03.220.

Republic of Bulgaria, Advisory Services on a National Climate Change Adaptation Strategy and Action Plan. “National Climate Change Adaptation Strategy and Action Plan.” 2019.
https://www.moew.government.bg/en/climate/international-negotiations-and-adaptation/adaptation/ (accessed November 6, 2021)

Republic Of Bulgaria Ministry of Energy Ministry of the Environment and Water. “Integrated Energy and Climate Plan of The Republic of Bulgaria 2021–2030.” 2021.
https://ec.europa.eu/energy/sites/default/files/documents/bg_final_necp_main_en.pdf (accessed November 6, 2021)

Resilience Alliance. (n.d.). Adaptive Cycle.
https://www.resalliance.org/adaptive-cycle (accessed November 6, 2021)

Sabbioni, Cristina & Cassar, M. & Lefevre, Roger-Alexandre. “Vulnerability of Cultural Heritage to Climate Change,” European and Mediterranean Major Hazards Agreement (EUR-OPA), 2008. www.coe.int/t/dg4/majorhazards/activites/2009/Ravello15-16may09/Ravello_APCAT2008_44_Sabbioni-Jan09_EN.pdf (accessed November 5, 2021)

Sesana, Elena, Alexandre S. Gagnon, Chiara Bertolin and John Hughes. *Adapting Cultural Heritage to Climate Change Risks: Perspectives of Cultural Heritage Experts in Europe*. Geosciences (Switzerland) 8, no.8 (August 2018): 305 doi: 10.3390/geosciences8080305

Sesana, Elena & Gagnon, Alexandre & Bonazza, Alessandra & Hughes, John. “An integrated approach for assessing the vulnerability of World Heritage Sites to climate change impacts”, Journal of Cultural Heritage 41. 2019. doi: 10.1016/j.culher.2019.06.013.

Sesana, Elena & Gagnon, Alexandre, & Ciantelli, Chiara & Cassar, Joann, & Hughes, John. Climate change impacts on cultural heritage: A literature review. *WIREs Clim Change*. 12:e710, 2021:2. doi: 10.1002/wcc.710.

Steffens, Karl. “Competences, Learning Theories and MOOCs: Recent Developments in Lifelong Learning” *European Journal of Education* 50, no.1, 2015:41-59 doi: 10.1111/ejed.12102

Thiele, Leslie Paul. *Sustainability*. 2nd ed. Cambridge: Polity, 2016: 36.

UN. (n.d.). Sustainable Development Goals: Goal 13: Take urgent action to combat climate change and its impacts.
https://www.un.org/sustainabledevelopment/climate-change/ (accessed November 5, 2021)

UN. (n.d.). What is Climate Change? Accessed November 5, 2021, https://www.un.org/en/climatechange/what-is-climate-change#.

UN. United Nations Framework Convention on Climate Change (Vol. 62220), 1992. https://unfccc.int/resource/docs/convkp/conveng.pdf (accessed November 6, 2021)

UN. The Paris Agreement, 2015. https://doi.org/10.4324/9789276082569-2 (accessed November 6, 2021)

UN. Transforming Our World: the 2030 Agenda for Sustainable Development, 2015. https://doi.org/10.1163/157180910X12665776638740 (accessed November 6, 2021)

UN. Secretary-General's statement on the IPCC Working Group 1 Report on the Physical Science Basis of the Sixth Assessment., 2021. https://www.un.org/sg/en/content/secretary-generals-statement-the-ipcc-working-group-1-report-the-physical-science-basis-of-the-sixth-assessment (accessed November 6, 2021)

UNESCO. Convention Concerning the Protection of the World Cultural and Natural Heritage. 2004. https://doi.org/10.5860/choice.41-5055 (accessed November 6, 2021)

UNESCO World Heritage Centre. *Policy document on the impacts of climate change on world heritage properties. Document WHC-07/16.GA/10 adopted by the 16th general assembly of states parties to the world heritage convention (October 2007).* https://whc.unesco.org/en/CC-policy-document (accessed November 6, 2021)

UNESCO. Convention Concerning the Protection of the World Cultural and Natural Heritage. (July 2019). https://doi.org/10.1007/978-3-319-01384-8_224(accessed November 6, 2021)

UNESCO, "Updating of the Policy Document on the impacts of Climate Change on World Heritage properties," Summary of the online consultation (30 December 2019 – 31 January 2020) https://whc.unesco.org/document/181913 (accessed November 6, 2021)

United Nations Environment Programme. 2021 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.2021. 2021 Buildings-GSR -Executive Summary ENG.pdf (globalabc.org) (accessed November 6, 2021)

UNSSC. The 2030 Agenda for Sustainable Development. 2015. https://www.unssc.org/sites/unssc.org/files/2030_agenda_for_sustainable_development_kcsd_primer_en.pdfwww.unssc.org (accessed November 6, 2021)

Walker, Brian, Holling, C., S., Carpenter, Stephen R. and Kinzig, Ann. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9, no. 2, 2004:5. doi: 10.5751/es-00650-090205