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ACTA DE GRADO No. 738

El día 23 de noviembre del año 2023, se reunieron en sesión solemne presidida por FRAY ERNESTO LONDOÑO OROZCO OFM. Rector y FRAY FRANCISCO LOTERO MATIZ OFM. Secretario, las Directivas de la Universidad De San Buenaventura Medellín, con el fin de otorgar a:

MANUELA MURILLO GALVIS

C.C. Nº 1.152.712.840 de Medellín

El título académico de:

MAGÍSTER EN BIOCLIMÁTICA

Programa registrado en el Sistema Nacional de Información de la Educación Superior SNIES con el código No. 103914 y con Registro Calificado según Resolución 001043 del 01 de mayo de 2022 del MEN.

Atendiendo al orden de la sesión establecido en el protocolo correspondiente para las ceremonias de graduación, el Decano de la Facultad presentó los graduandos, certificó el cumplimiento de los requisitos exigidos, y solicitó al Rector les fuera otorgado el correspondiente título. Posteriormente el Secretario dio lectura a la Resolución No. 103 de fecha 23 de noviembre de 2023, por la cual se conceden Títulos Académicos. Acto seguido, el Rector tomó el juramento de rigor e hizo entrega del Diploma y el Acta de Grado que los acreditan como Profesionales de esta Universidad.

En constancia se firma esta acta y se inscribe en el Libro 3, Folios 196-197, bajo el registro No. 24456.

Dada en Medellín, Antioquia, el día veintitres (23) de mes de noviembre del año dos mil veintitres (2023).

FRAY FRANCISCO LOTERO MATIZ OFM.
SECRETARIO

UNIVERSIDAD DE SAN BUENAVENTURA

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MINISTERIO DE EDUCACIÓN NACIONAL DE LA REPÚBLICA DE COLOMBIA

CONFIERE A

MANUELA MURILLO GALVIS

C.C. 1.152.712.840 de Medellín

EL TITULO DE

MAGISTER EN BIOCLIMÁTICA

En testimonio de ello le otorga el presente diploma en
Medellín, Antioquia, el 23 de noviembre de 2023

Rector

Decano(a)

Fr. Francisco

Secretario

Anotado en el folio 196-197 del libro 3 de Registro de Diplomas, bajo el número 24456,
el 23 de noviembre de 2023

32293

Medellín, 15 de enero de 2026

La B S.A.S.

Certifica que:

La Arquitecta **MANUELA MURILLO GALVIS** identificada con cédula de ciudadanía número 1.152.712.840 de Medellín, se ha desempeñado en esta empresa como Asesora Bioclimática desde el 01 de septiembre de 2021, hasta la fecha, participando en los siguientes proyectos:

Cod.	PROYECTO	CONTRATANTE	LOCALIZACIÓN	LABOR	ÁREA (M2)	AÑO
1	CAM Y PAO	Centro Administrativo Municipal de Bello	Bello, Antioquia	ASESORIA DESEMPEÑO TERMICO Y CALIDAD DEL AIRE	3.154	2021
2	Vivienda Manizales	Carolina D'Koller Arquitectura	Manizales, Caldas	ASESORÍA BIOCLIMÁTICA	350	2022
3	Vivienda Rionegro	Carolina D'Koller Arquitectura	Rionegro, Antioquia	ASESORÍA BIOCLIMÁTICA	534	2022
4	COLSANITAS El Poblado	Sopórtica	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	1995	2022
5	Velódromo de Bogotá	Área 4	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	11257	2023
6	Fundación UdeA	Convel	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	3250	2023
7	Edificio Soul Colpatria	Colpatria	Envigado, Antioquia	ASESORÍA BIOCLIMÁTICA	8808	2023
8	Casa La Reserva	Sofía Restrepo	Rionegro, Antioquia	ASESORÍA BIOCLIMÁTICA	340	2023
9	Hotel Poblado Plaza	Hoteles Poblado	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	2782	2023

10	Plan Integral IUPB	Fundación Pascual Bravo	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	N/A	2023
11	Aeropuerto Internacional de Lima	Consorcio Inti Punku	Lima, Perú	ASESORÍA BIOCLIMÁTICA Y ESTUDIO DE ERGONOMÍA Y FACTORES HUMANOS	N/A	2023
12	Centro hospitalario Tatamá	Fundación Santa Fé de Bogotá	Pereira, Risaralda	ASESORÍA BIOCLIMÁTICA	36857	2024
13	Unidad Deportiva el Salitre (UDS)	CONSORCIO CENTRO DEPORTIVO 011	Bogotá, Cundinamarca	ASESORÍA BIOCLIMÁTICA Y CERTIFICACIÓN	10100	2024
14	Bodega de Vélez	Cueros Vélez	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	2.037	2024
15	Colegio Sagrado Corazón Montemayor | Primaria	Convel | Ángela Arias	Rionegro, Antioquia	ASESORÍA BIOCLIMÁTICA	3.700	2024
16	Coliseos Deportivos - San Marcos y San Francisco	FP Arquitectura | Ángela Arias	Medellín, Antioquia	ASESORÍA BIOCLIMÁTICA	2038	2025
17	Termales Santa Rosa	OPUS | Paula Tobón	Santa Rosa de Cabal, Risaralda	ASESORÍA BIOCLIMÁTICA	3904	2025

La presente certificación se expide a solicitud de la interesada.

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Passive design strategies on climate change scenarios

Estrategias de diseño pasivo en escenarios de cambio climático

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Abstract

Climate change has driven humanity to develop strategies aimed at slowing its progression, mitigating its negative impacts, and adapting to the new climatic reality we are already facing. However, the lack of precision in projections of future changes in temperature, relative humidity, precipitation, solar radiation, among other variables, hinders the formulation of concrete mitigation and adaptation strategies, particularly at local or regional scales. Despite this, there are recognized efforts to define future climate change scenarios, to elaborate future weather data files, and to establish future comfort ranges, which could facilitate, among other aspects, the prediction of changes in the bioclimatic performance of buildings. This paper aims to review recent advances in forecasting the bioclimatic performance of buildings under future climate scenarios, based on a systematic review of 101 studies. The findings were grouped into categories that enabled conclusions about both scientific progress and existing gaps in the field. The review preliminarily suggested that passive design strategies in naturally conditioned buildings, as well as in those dependent on heating and cooling systems, may be insufficient under projected climate conditions. Therefore, it highlights the need for more reliable future climate data to decisively incorporate climate change–aligned strategies into architectural or urban design decision-making—along with the need for more studies on these topics, particularly in tropical regions..

Keywords: Climate change scenarios, passive design strategies, future adaptive thermal comfort, weather files.

Resumen

El cambio climático ha impulsado a la humanidad a desarrollar estrategias para reducir su avance, mitigar sus impactos negativos y adaptarse a la nueva realidad climática que ya estamos enfrentando. Sin embargo, la falta de precisión sobre los futuros cambios en temperatura, humedad relativa, precipitación, radiación solar, entre otros, afecta la determinación de estrategias concretas de mitigación y adaptación, principalmente a nivel local o regional. A pesar de esto, se reconocen esfuerzos por determinar escenarios de cambio climático, elaborar archivos climáticos futuros y establecer rangos de confort hacia el futuro que facilitarían, entre otros, la previsión de cambios en el desempeño bioclimático de edificaciones. Este artículo se propuso revisar avances en la previsión de desempeño bioclimático de edificaciones en escenarios futuros, a partir de la revisión sistemática de 101 investigaciones. Los resultados se agruparon en categorías que permitieron concluir acerca de los avances científicos y las brechas de investigación en este campo. La revisión permitió concluir, preliminarmente, que las estrategias de diseño pasivas en edificios acondicionados naturalmente, así como en los que dependen de sistemas de calefacción y refrigeración, podría ser insuficientes. Por tanto, se resalta la necesidad de contar con información climática de escenarios futuros más confiable, de manera que se incorporen, de manera determinante, estrategias alineadas con el cambio climático en la toma de decisiones proyectuales en edificaciones o espacios urbanos y se cuenten con más estudios sobre estos temas, principalmente en la región tropical.

Palabras clave: Escenarios de Cambio Climático, Estrategias de diseño pasivo, confort térmico adaptativo futuro, Archivos climáticos futuros.

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INTRODUCTION

Climate change is the result of a massive increase in greenhouse gas (GHG) emissions caused by burning fossil fuels, it impacts not only the scientific field, but also the economic, social, political, and individual dimensions. This challenge is considered the greatest scientific problem of the XXI century (Maslin, 2002), demanding the urgent need to keep the global temperature increase below 1.5°C relative to pre-industrial levels. This problem of humanity is even proposed as one of the Sustainable Development Goals of the United Nations, SDG 13 "Climate Action".

According to the most recent report of the Intergovernmental Panel on Climate Change (IPCC), an increase in global temperatures of between 2.6 and 4.8°C is projected by the end of the XXI century, compared to the period between 1986 and 2005. This projection of global warming entails multiple challenges, such as the significant increase in energy demand by cooling systems (Berardi & Jafarpur, 2020). This phenomenon not only poses energy challenges but also highlights the urgent need to address climate change and develop innovative approaches to address its imminent adverse effects.

The Nationally Determined Contributions (NDCs) are at the heart of the Paris Agreement and commit to aligning financial flows with low greenhouse gas emissions and climate-resilient development. These measures, aimed at achieving adaptation and mitigation goals, must evolve over time (UN, 2015). Global emissions projected in the NDCs prior to COP26 could lead to warming exceeding 1.5°C and it will be challenging to keep it below 2°C after 2030 relative to pre-industrial levels (IPCC AR6 WG III, 2022). This underscores the urgent need to update the NDCs.

Climate change is leading to extreme weather events such as heat waves and heavy precipitation, altering weather conditions to an unprecedented extent in many centuries or even millennia (IPCC WGI, 2021). Greenhouse gas emissions continue to increase, with an increase of 12% between 2010 and 2019. Buildings are responsible for 6% of global GHG emissions, which represent 16% of global net anthropogenic emissions if energy production emissions, for these buildings, are included. Furthermore, emissions in urban areas have experienced significant growth, from 62% in 2015 to 72% globally in 2020, due to complex factors such as population growth, rising incomes, and urbanization patterns (IPCC AR6 WG III, 2022).

Climate change also affects the solar radiation that reaches Earth. According to Wild (2009), a variation in solar radiation has been observed, with a significant decrease in many places during the period from 1960 to 1990, especially in densely populated areas. However, from 1990 to 2009, most places experienced an increase in global radiation, although some exceptions still show decreasing trends. This variation in radiation is due to multiple factors, such as the properties of clouds, changes in atmospheric gases, such as water vapor, which absorbs solar radiation, and aerosol characteristics, which can scatter or absorb radiation depending on their composition. Although Earth's orbital parameters also play a role, the main drivers of these variations are changes in cloudiness, aerosols, and their interactions.

Given this scenario, it is strategic to have detailed future climate models, so that it is feasible to predict, with better precision, the future bioclimatic performance of buildings, explore the best architectural or urban strategies, and establish the external climatic conditions to which people will have to adapt. This paper presents a state-of-the-art review of scientific publications that explore climate change and architectural design strategies. The aim is to understand how the field has integrated climate scenarios into design practice, identify key advances, and highlight ongoing challenges. This review offers a valuable contribution by clarifying current relationships between climate and architectural or urban design, while supporting future research toward more resilient and adaptive architecture.

METODOLOGY

Climate change impacts are becoming increasingly complex, interacting simultaneously in various areas such as environmental, economic, and social, and posing multiple regional risks according to vulnerability. These impacts are closely linked to short-term mitigation measures (Pereira et al., 2022). Risks are evaluated in terms of economic and non-economic damages and losses, projected in three time periods: short-term (2021-2040), medium-term (2041-2060), and long-term (2081-2100).

At the local and regional levels, the precise determination of climate risks in future scenarios is complex, given the lack of knowledge on the potential effects of climate change. These models still present uncertainty due to the lack of scientific consensus when modeling local climate change effects, which is known as "model uncertainty" and contributes to the evaluation of the accuracy of estimates at smaller scales (Fonseca et al., 2020).

Despite these limitations, incorporating future climate scenarios remains essential for anticipating potential impacts and informing adaptive design strategies. Therefore, the following section explores the framework of climate change scenarios used to project future conditions and guide decision-making under uncertainty.

In order to carry out a methodical literature review on the advances in the study of the bioclimatic performance of buildings under future scenarios, an exhaustive search of scholarly articles was conducted focusing on the following topics:

- Climate change scenarios and design strategies in buildings

- Future weather files
- Future thermal performance and energy consumption of buildings
- Radiation, daylighting, human well-being, and energy efficiency

The review covered studies published between 1982 and 2023, with particular emphasis on research from the last decade to capture the most recent developments and methodological approaches.

Climate change scenarios

In 1990, the IPCC's Working Group III developed four future emissions scenarios known as SA90, which were then used as the basis for creating six additional GHG emissions scenarios called IS92 by the IPCC's Working Group I. These scenarios were used to estimate and mitigate possible climate change, using climate and gas cycle models that relate emissions to atmospheric concentrations (Mitchell & Gregory, 1992). In 1996, the IPCC created future climate scenarios called IE-EE, which considered the carbon intensity of the energy supply, income inequality between developed and developing countries, and sulfur emissions. These scenarios build futures based on GHG emissions, all considered equally valid without assigning probabilities of occurrence.

The Special Reports on Emission Scenarios (SRES) are generated using dynamic systems and are used to assess impacts and adaptation and mitigation strategies. They are divided into four families (A1, A2, B1 and B2), each characterized by different demographic, economic and technological trends (Intergovernmental Panel on Climate Change. Working Group III, 2000), see Table 1.

The IPCC has subsequently developed a future scenarios framework that encompasses climate, social, economic and climate change adaptation and mitigation responses. These scenarios are known as the Representative Concentration Pathways (RCPs), Shared Socioeconomic Pathways (SSPs) and Shared Policy Assumptions (SPAs). However, despite its importance, this framework has been scarcely applied in the architectural context (Kebede et al., 2018).

The Shared Socioeconomic Pathways (SSPs) are divided into five categories (SSP1, SSP2, SSP3, SSP4 and SSP5) and offer an integrated assessment of climate change-related issues. Each category projects trends in greenhouse gas emissions considering factors such as population growth, technological development and GDP in different regions (Chen et al., 2017).

Table 1. Global warming scenario categories, according to AR6

				Change in median global temperature °C	
Scenario	Description	Aligned to SRES	Aligned to SSP	Heating peak	Year 2100
C1	Limit warming to 1.5°C (>50%) with limited or null excess			1.6	1.3
C1a	Limit warming to 1.5°C con (GHG) Net Zero Protocol	B1	SSP1-1	1.6	1.2
C1b	Limit warming to 1.5°C without GHG Net Zero			1.6	1.4
C2	Returning warming to 1.5°C (>50%) after surpassing the top limit			1,7	1,4
C3	Limiting warming to 2°C (>67%)			1,7	1,6
C3a	Limiting warming to 2°C starting actions by 2020		SSP1-2,6	1,7	1,6
C3b	Limiting warming to close to 2°C Nationally Determined Contributions (NDC) up to 2030			1,8	1,6
C4	Limiting warming to 2°C (>50%)			1,9	1,8
C5	Limiting warming to 2.5 °C (>50%)			2,2	2,1
C6	Limiting warming to 3°C (>50%)		SSP2-4,5	temperature does not	2,7
C7	Limiting warming to 4°C (>50%)	A2	SSP3-7	reach its maximum in	3,5
C8	Exceed 4°C warming (>50%)	A1	SSP5-8,5	2100	4,2

Note: Adaptation of global warming scenario category table (Arango Díaz et al., 2022)

These pathways build on previous scenario frameworks and allow for comparison across time. Table 1 summarizes the evolution of scenario families, showing how different frameworks have approached future climate projections. For instance, Strandsbjerg Tristan Pedersen et al., (2021) have conducted research that compares different climate change scenarios, including SA90, IS92, SRES, and SSP. The research focused on analyzing family scenario narratives by grouping them into five categories: “global-sustainability,” “regional-sustainability,” “middle-of-the-road,” “regional-competition,” and “rapid-growth.” It was found that the first and last category represent the lowest and highest accumulated emissions pathways, respectively.

SSP, RCP

Based on previous processes to address climate change and led by the research community, cross-disciplinary scenarios have been created at the global, regional, and field levels that evaluate aspects such as atmospheric composition, the scope of future climate change, potential impacts on natural and human systems, as well as the cost, effectiveness, and policies of mitigation and adaptation. These scenarios include atmospheric concentration trends and socioeconomic pathways related to emissions and climate change (Ebi et al., 2014), as shown in Table 2.

Table 2. SSP and RCP scenario generation

Authors	Description
(O'Neill et al., 2014).	Phase 1: Creation of 4 Representative Concentration Pathways (RCPs) and analysis of emissions and influencing factors. Phase 2: Creation of Integrated Assessment Models (IAMs) and Impacts of Adaptation and Vulnerability (IAV). Simultaneously, Shared Socioeconomic Pathways (SSPs) are developed to describe future socioeconomic trends.
(Ebi et al., 2014).	Phase 3: As a third phase, integrated scenarios are created to describe socioeconomic development with projections of climate change and assumptions about climate adaptation and mitigation policies. There are several plausible scenario combinations, for example, only SSP5 (associated with the highest economic growth level) could be fully compatible with RCP8.5 and lead to emission levels that are consistent with RCP8.5, while there are other scenario combinations that would not be possible.
(Kebede et al., 2018).	Each combination of the SSP and RCP scenarios represents a macroscale family of scenarios. The SPAs (Shared Policy Assumptions) represent the last component of the global scenario framework, capturing key policy attributes such as the objectives, instruments, and obstacles of mitigation and adaptation measures.

Source: original work

In all possible future climate scenarios, the global surface temperature will continue to rise until at least mid-term (2040-2061). Global warming of 1.5 °C and 2 °C will be exceeded during the 21st century unless there are deep reductions in CO2 and other greenhouse gas emissions in the coming decades. (IPCC WGI, 2021)

Climate files

Weather data is essential for achieving accurate simulations, as it significantly influences the results obtained. To ensure the accuracy of simulations, updated and reliable climate information from various regions of the world is required.

It is crucial to remember that, although climate files may accurately reflect current climate conditions, the climate can experience significant changes over decades, which is the typical lifespan of buildings. Therefore, it is essential to consider possible variations in weather conditions, modifying files with climate change trends for a review of energy consumption and habitability conditions in future scenarios (Yan et al., 2022; Yassaghi, Mostafavi, 2019)

To calculate temperature variations in a specific region according to IPCC scenarios, global climate models are used. These models combine information on the atmosphere, hydrosphere, biosphere, and lithosphere to simulate current and future climate conditions.

Temperature variations can be calculated by comparing future conditions with current conditions. IPCC scenarios describe different possible futures in terms of greenhouse gas emissions, demographic trends, economy, technology, energy, food, and policies (IPCC AR6 WG III, 2022).

Climate models, as predictive tools, possess uncertainty in their results, which requires a probabilistic approach to consider various future possibilities. To adjust data in climate files according to IPCC scenarios on climate change, there are available software and methodologies, such as global climate models, regional temperature projections, climate analysis tools, and scenario analysis programs.

Through climate models, it is possible to have data in areas without weather stations using assumptions and statistical relationships. The choice of model and parameters can affect accuracy. Climate change files are based on future scenarios with assumptions about emissions and land use. Accuracy decreases when projecting into the future due to uncertainty in models and assumptions (see Table 3).

Table 3. Future climate file generators

Generator	Methodology	Applied technique	Based on	Produces files with extensions
Meteonorm	Produces results for nine future time intervals (from 2020 to 2100) using three emission scenarios (A1B, B1 and A2) from the fourth evaluation report of IPCC (P.tootkaboni et al., 2021). It generates detailed data, considering several variables such as temperature, solar radiation, humidity and wind (Jiménez Torres et al., 2023).	Stochastic	8325 meteorological stations	Typical Meteorological Year (TMY) y Energy Plus Weather (EPW)

CCWorldWeather Gen (Morphing)	Uses indicated data with A2 emission scenarios to create future meteorological data sets (Belcher et al., 2005).	Morphing	Met Office and Hadley Center Coupled Model 3 (HadCM3) with other General Circulation Models (GCM) CMIP2	(TMY2) y (EPW)
WeatherShiftTM	Combines data from (GCM) models simulated in two emission scenarios (4.5 y 8.5, known as Representative Concentration Pathways - RCP) using the morphing technique. (Troup & Fannon, 2016).	Morphing	14 (GCM) CMIP5	Cumulative Distribution Function (CDF)
Weather Morph: Climate Change Weather File Generator	The tool includes carbon emission scenarios B1, B2 and A1FI, except scenario A2. IPCC HadCM3 files are pre-loaded (Jiang et al, 2019).	Morphing	Met Office and Hadley Center Coupled Model 3 (HadCM3)	(EPW y TMY2)
Vatic Weather File Generator (VWFG)	Generator of future Climate files, using historic data and covering scenarios (RCP) 4.5 y 8.5 to generate a scale reduction. (Aliabadi & McLeod, 2023).	Statistic scale reduction	Climatic Model CanRCM4 (1980–2100) and ERA5 as climate file record	(EPW)
The Morph EPW App	Uses the morphing method introduced by Belcher et al. (2005) to modify EPW weather files by applying projected changes from (GCMs) to local climate variables in a simplified way.	Morphing	CMIP6 GCM Models	(EPW)

Future Weather Generator (FWG)	This open-source software is based on the historical climate period from 1985 to 2014 and generates future timeframes for mid-century (2050: 2036–2065) and late-century (2080: 2066–2095) scenarios. Using these reference periods, it calculates monthly changes in climate variables according to the four (SSPs). (Rodrigues et al., 2023)	Morphing	CMIP6 GCM Models	(EPW)

Source: original work

Note: Downscaling are techniques based on statistical relationships to produce synthetic meteorological temporary series // Morphing to adjust current meteorological data with meteorological forecast data.

Yassaghi et al., (2019) state that there are discrepancies between the two software for transforming climate files, the files modified in Meteonorm present more extreme minimum temperatures while they show a lower increase in maximum temperatures compared to the files modified in CCWorldWeatherGen

In a study by Gonzales et al. (2017), they compared two sources of climate data: a generator based on data from local weather stations and the Meteonorm Typical Meteorological Years. They found high agreement in some cities, indicating similarity in climatic conditions. Meteonorm uses 8,325 weather stations to generate detailed data, considering various variables such as temperature, solar radiation, humidity, and wind (Jiménez Torres et al., 2023).

Meteonorm uses several databases combined into one integral system to simulate the environment. In South America, they consider 660 stations: 75 with radiation and temperature, 572 with temperature and other parameters, and 13 with only temperature or radiation (Remund et al., 2014).

With a statistical approach and a wide network of stations, Meteonorm's climate files are essential for analyzing energy in buildings and thermal systems. These files allow simulation of different scenarios, providing climate details to evaluate performance and optimize the design and operation of buildings and systems Gonzales et al. (2017). However, the generation of these files has some uncertainty due to the variability in the quality and availability of data from multiple stations and climate models.

Given the unpredictability of climate change and the difficulty of obtaining accurate data, Meteonorm's climate files are useful, but with some degree of uncertainty. Faced with the variability of climate change, the available sources for future data are based on previous climate projections, generating uncertainty

(Medina-Patrón & Escobar-Saiz, 2019). Therefore, it is important to use multiple sources and validate with observed data for a complete and reliable understanding of climate in a specific location.

However, in addition to the uncertainty of future climate scenarios, the increase in the frequency and intensity of extreme weather events is added when addressing the impacts of climate change. According to Moazami et al. (2019), the inclusion of climate files that cover both typical and extreme future conditions significantly improves the reliability of the results, especially when studying short-term variations. These studies indicate that energy demand could increase by up to 28.5% more compared to typical future conditions.

On the other hand, facing the changes, conventional methods for measuring energy consumption in buildings may lack precision due to the uncertainties present in future climate models. To assess the overall performance of a building and address climate uncertainties, probabilistic approaches are required. They employ extensive datasets from climate projections with detailed spatial and temporal resolution, as well as considerable computational resources.

Yassaghi et al. (2020) proposed a method for propagating climate uncertainty, which combines regression techniques, distribution fitting, and random sampling. This approach allows climate uncertainties into simulation tools, being applicable in situations where the availability of future meteorological files is limited. It is a probabilistic model designed to capture the predicted trends in energy performance of buildings, being useful in regions with restrictions due to the availability of future meteorological files to integrate them into building simulation tools.

Instability of climate change and solar radiation

Climate change depends on geographic location and latitude. In tropical regions, the effects can fluctuate even within a single day. During a typical day, it is possible to experience intense lighting conditions under a clear sky in one part of the day and, at another time, face heavy rain with significantly lower lighting levels. This variability and lack of uniformity in the distribution of daylight makes it difficult to choose the best lighting strategy, as optimal conditions may not always be available. Climate change can lead to diverse climatic extremes depending on location, which will have a major impact on the availability of light in the future (Wittkopf et al., 2007).

According to Antuña et al. (2011), in the Caribbean, a decrease in radiation has been observed, especially in continental areas, which represents approximately 80% of the cases evaluated. Whereas, in insular areas, the increase and decrease in radiation are balanced in similar proportions.

This pattern of radiation decrease is related to the geographic characteristics of each area and is more pronounced in densely populated areas, due in part to urbanization. Areas with high industrial activity experience greater reductions in radiation, while in less populated places an increase in radiation is sometimes recorded. This suggests a local or regional connection between human activity and solar radiation, rather than a global effect. Over the decades, a darkening of up to 2.7% has been recorded, although recently there has been an increase in brightness, possibly due to regulations that reduce aerosol emissions (Alpert et al., 2005), see Table 4.

Table 4. Variations in radiation in different regions and time periods

Authors	Study	Main Conclusions
Brazel & Tomalty (2021)	Variation of solar radiation in Arizona (1950-2020)	The results of the study showed attenuations of up to 13%. This attenuation was attributed to air pollution associated with urban growth
Akemi Yamasoe et al. (2021)	Variation of solar radiation in Sao Paulo, Brazil (1961-2016)	Negative trend in global radiation between 1961 and 1980. Continued negative trend, influenced by climate factors and human activities.
Li et al. (2022)	Evaluation of radiation in the East of China (1961-2018)	Significant decrease in radiation between 1961 and 1999. Marked increase between 2010 and 2018. Variability between regions in the period 2000-2010.
Julsrud et al. (2022)	Variation of global radiation in United States, China, Japan and Europe (1961-2014)	Decrease in radiation between 1961 and 1980, followed by a slight increase from 1980 to 2000. Atmospheric component's role in variations.

Source: Original work

There is a contradiction between global warming and attenuation that remains unresolved, the negative shortwave forcing is greater than the estimated increase in positive longwave radiative forcing that has occurred since the industrial era because of the combustion of fossil fuels and biofuels. The scientific consensus on global warming is based on the explanation of Earth's warming due to the increase in the concentration of greenhouse gases, which cause longwave warming (Stanhill, 2007).

These variations in global radiation not only have thermal implications but also affect the availability of light in different regions. Therefore, it is essential to consider these possible fluctuations when analyzing future climate change scenarios.

Lighting plays an essential role in human well-being. Daylight in office environments improves color reproduction and increases user productivity compared to artificial light (Yu & Su, 2015). In addition, the preference for daylight goes beyond comfort and energy efficiency. People have a physical and psychological connection with natural cycles, which benefits their health. In addition, it reduces energy consumption for artificial lighting; therefore, the use of daylight is crucial to advance towards office buildings with near-zero carbon emissions (Joarder et al., 2019).

Daylighting is considered the best source of light in terms of color reproduction, as it offers a more accurate and balanced visual response than other sources (Alrubaih et al., 2013). Despite the fluctuations throughout the day, it is often complemented with artificial lighting. It is essential to maintain adequate levels of illumination to ensure visual comfort and prevent glare. By combining natural lighting systems with artificial lighting, it is possible to significantly improve energy efficiency and reduce environmental pollution.

Energy demand and thermal comfort

Climate change will affect all regions of the planet, but developing countries in the tropics, characterized by high temperatures and humidity throughout the year, will be more affected by climate change (Hashemi, 2018). It poses significant challenges given the precarious living conditions in some areas and the present and future thermal performance of buildings. It is predicted that temperatures in countries with tropical climates, such as Colombia, will be higher in the future, with a projected increase of 1°C for the period 2011-2040 compared to 1971-2000, and an increase of 2 to 3°C for 2040-2070 (IDEAM & UNAL, 2018).

The increase in energy consumption in the context of climate change is undeniable. Nguyen et al., (2021) showed that an existing building could have an increase of 7.2% to 12.3% in total energy consumption and a significant increase in the overheating period in the future. In Colombia, for example, the demand for air conditioning increased significantly, by 72% between 2013 and 2018, which exceeds the growth observed in neighboring countries such as Brazil, Argentina, Mexico, Panama, and even Chile (Estupiñan, 2020).

This is even more critical given the high sensitivity of indoor temperature and the demand for refrigeration, as shown by the study of Serasinghe et al. (2022). When the outdoor temperature is increased by 1°C, the increase in the demand for refrigeration is 25% in the present scenario, and up to 40% and 50% by 2050.

The problem of climate change in architecture can be discussed from three approaches: one is safety to minimize risks associated with natural disasters, the second approach has considered strategies to reduce greenhouse gas emissions, and the third approach is based on habitability, addressing bioclimatic performance (Arango Díaz, Herreño Tellez et al., 2022). The adaptation of architecture to climate change from the perspective of habitability is addressed to improve the conditions of existing buildings or to design new buildings.

Based on exploring the effect of climate change when designing variables on a building, Bamdad et al. (2021) perceived that, from an energy efficiency perspective, the strategies to achieve optimal conditions in buildings can vary between current and future climate change scenarios, particularly in the demand for cooling. Additionally, it was found that these variations are considerably different depending on the city evaluated. This suggests that architecture will have to adapt to new environmental conditions that pose new challenges, considering the impact of climate change on the design in relation to architectural envelopes (walls, windows, roof and floors), building technology, and their operation (Jakob & Catenazzi, 2007).

In more recent stages, research has focused on analyzing the reduction of the carbon footprint throughout the entire life cycle of the building (Skullestad et al., 2016). As indicated above, energy saving has been replaced by a more relevant role of the building, from maximum saving, minimum consumption, or zero balance (Cellura et al., 2014) to energy-producing and resource-producing buildings. According to it, the operational phase of buildings represents an important percentage of energy consumption and greenhouse gas emissions (Chateau et al., 2020). As indicated, some authors recommend more actions based on uncertainty in order not to spend more time and resources than necessary on incorrect actions (De Souza et al., 2015).

On the other hand, another factor that increases the pressure on the planet is the increase in population to 54% in urban areas, which is predicted to reach 66% by 2050 (United Nations, 2014) and energy demand has important environmental and social implications. On the one hand, cities are responsible for greenhouse gas emissions and other atmospheric pollutants, with an impact on climate change, air quality, and the health of urban dwellers. On the other hand, the growing energy demand can also affect energy security and the economy of countries and regions (Xue & Liu, 2022).

Global warming affects habitability due to the overheating of indoor spaces and urban areas (Masson-Delmotte et al., 2019). In addition, the increase in temperature, urbanization, and hard surfaces, worsens heat islands impacting energy consumption (Santamouris, 2016). The orientation of streets where buildings are located plays an important role in thermal performance. Some studies have analyzed the relationship between building typology and different environmental parameters, such as ventilation potential and cooling load related to urban design (Abdollahzadeh & Biloria, 2022).

Heating vs refrigeration

In general, the amount of energy required for heating has been greater than that required for cooling in a global scenario. However, this trend may be reversed in the climate change scenario, as evidenced by research conducted in different places with different climates, such as the research conducted by Yassaghi, Hoque et al. (2019), in which they demonstrated through simulations in scenarios with base conditions and projected scenarios up to the year 2080, that future buildings will experience a significant increase in energy consumption for cooling, accompanied by a decrease in energy consumption for heating.

In India, a simulation methodology with DesignBuilder based on 3 existing concrete buildings demonstrated that while there is a decrease between 59.8% and 81.2% of energy demand for heating in the predictive scenarios of 2050 and 2080, the energy requirement for cooling increased at much higher levels between 221.9% and 467% for the same periods, respectively (Thapa et al., 2023).

In Iran, with a warm and dry climate, the research conducted by (Rodrigues et al., 2023) based on the simulation of 12,000 buildings, showed an increase in temperature of 4° (2050) and 8°C (2080), with a direct relationship between the increase in the demand for cooling depending on the location, being much higher the increase percentage in coastal areas (between 8 and 13%) compared to the increase in the interior or mountainous areas (between 12% and 20%).

Research carried out throughout Europe confirms the statements, on the one hand, the increase in temperature between the years 2050 and 2080, with a progressive decrease in energy demand for heating, compared to the increase for cooling, especially in the southeast of Europe, where there is also a high CO2 emission intensity. As a conclusion, the authors warn about a risk of greater impact on Mediterranean areas than the rest of Europe (Ciancio et al., 2020).

Not only the differences between countries, but also those of architectural typology, can make a difference, as shown by research conducted in Canada in high-rise residential buildings by the National Energy Code of Canada for Buildings (NECB), and Passive House (PH). In both cases, the demand for heating can decrease, while the demand for cooling can increase by up to 50% in the 2080 scenario, and the PH Case would no longer meet the requirements. While in cold areas, greater energy savings between 5% and 30% can be achieved, depending on the location (Mutasim, Baba & Ge, 2019).

In the UK, it has also been shown that the historical trend has been changing, on the one hand, the heating days degrees have decreased between 11 and 19% compared to the period 1961-2006 (Wilde & Tian, 2010); on the other hand, internal loads have increased due to a larger number of buildings with glazing on the facades and thermal insulation (Jakob & Catenazzi, 2007).

In research conducted by Fürtön et al. (2022) in Hungary, Portugal and Lithuania with IPCC RCP4.5 scenarios, they compared the energy consumption for heating and cooling in 2050 and 2100, showing a greater impact of up to 69%. The continental climate of Budapest is the most threatened by summer overheating, with an increase of 69% for the ODH26 indicator. A more balanced warming was found for Lisbon (23%), and moderate changes for the city of Kaunas (a 153% increase from a very low base).

In response to the above, several countries have adopted measures, such as Japan, which proposed a set point of 28°C for cooling. The government of Malaysia also promotes 24°C as a set point for offices (Tsutsumi et al., 2007). However, despite the positive effect of these measures, in countries with warm and humid climates, thermal preferences must be considered depending on the region. For example, in countries such as Pakistan, Cuba, Nepal, and India, comfortable temperatures have been found up to 30°C (Damiati et al., 2016).

In countries with seasons, climate change scenarios could lead to a decrease in the energy requirement for heating that would exceed the increase in the need for energy for cooling, a direct consequence of rising temperatures (Yang et al., 2014). This phenomenon could result in a possible balance or even a global reduction in energy consumption for air conditioning during the projected climate change (Bienvenido-Huertas et al., 2020).

Passive design strategies

The negative impact of climate change on buildings and their vulnerability is largely due to the poor quality of the envelope, which is unable to provide the insulation or ventilation necessary to generate thermal comfort indoors, so it is replaced by active strategy systems with high energy consumption.

Comfort in spaces, both in new buildings and in the improvement of existing ones, has been based on the idea of fossil fuel consumption (Cooper, 1982), given the unsustainable patterns of energy consumption promoted by the international standard (Spaargaren, 2005). According to Francis et al. (2023), the adoption of the concept of sustainable construction as a response to mitigate climate change can provide significant benefits. These benefits cover social, cultural, energy conservation, and the improvement of indoor air quality, thus contributing to the environmental comfort of users.

However, unsustainable patterns of energy consumption persist and promote that the entire society inhabits climatically homogeneous spaces, against which authors such as Wang et al. (2021) warn about the necessity to review the discomfort ranges, to make it feasible to apply bioclimatic or passive design strategies to achieve this.

In this framework, passive design or bioclimatic strategies take advantage of the environmental characteristics of a region to improve thermal, lighting, and energy performance (Montoya et al., 2023). Rockwood et al. (2015) suggest that the implementation of passive strategies, such as shading and ventilation, can significantly reduce thermal discomfort in buildings. In this same line, research carried out by Ran et al., (2023), used an algorithm (NSGA-II) to optimize key parameters of the building envelope, in cities in different climatic regions of China, demonstrating that each city needs the implementation of different strategies, and that energy consumption can be reduced by 14.5~24.0 % and thermal comfort can be improved by 23.8~34 %, with an increase of 27.0~35.3% in initial costs.

Shading, for example, can reduce the amount of direct solar radiation that enters the building and, therefore, reduces the amount of heat accumulated inside. Ventilation, on the other hand, can improve air circulation inside the building and promote the exchange of fresh air outdoors, which can help to reduce the heat and humidity feeling inside. The authors also pointed out that these passive strategies are particularly effective in warm and humid climates (Rockwood et al., 2015). In addition to shading and natural ventilation, the reduction of direct solar gains, showed to be the most effective design strategies to counteract climate change in future buildings (Flores-Larsen et al., 2019).

The possible energy reduction does not depend solely on the incorporation of a single strategy, but on the combination of factors such as climate, building type, building program, orientation, window opening control strategies, envelope, ventilation, and the set point inside. In naturally ventilated buildings with hybrid ventilation, significant savings can be achieved. Some authors argue that between 20% and 45% (Sánchez García et al., 2019), 48% in Warm and Dry Climates according to Duan et al., (2022); and in contexts such as the Mediterranean up to 73% (Chiesa & Grosso, 2015)

The potential use of natural ventilation (NV) as a strategy for energy saving has been studied in several research projects, such as the one developed by Chen et al. (2017), which shows the benefits of natural ventilation based on Building Energy Simulation (BES) for subtropical and Mediterranean climates. In other climates, such as desert climates in the Middle East and central Australia, night ventilation may be more beneficial.

Studies conducted on buildings with NV have shown the benefits of implementing additional design strategies, based on experimental simulation models. For example, NV combined with strategies to reduce the U-value of walls and solar absorption coefficient and increase the shading coefficient to 0.25, were able to reduce indoor temperatures in medium and upper levels, avoiding the increase in temperatures caused by climate change of up to 1.2 °C (Chow & Levermore, 2010). However, other studies, such as the one conducted by Orme & Palmer (2003), have shown that passive strategies can be conservative in the long term and that these buildings may eventually require air conditioning.

Natural ventilation is not only beneficial in tropical or temperate climates, but also in countries such as the United Kingdom, which has four distinct seasons. In a study conducted in several UK cities under the UKCIP02 scenario, it was demonstrated through simulation that the use of passive design strategies, especially natural ventilation, is feasible not only in the present, but also in the future (up to 550 years) to provide the necessary comfort and reduce energy consumption (Hacker & Holmes, 2007).

However, the increase in the number of office buildings with glazed and closed facades, because of modernization, leaves air conditioning as the only alternative. This is why the energy consumption derived from air conditioning has increased to more than 50% of the total consumption in countries such as Saudi Arabia and Malaysia, a situation similar to others with warm and humid climates (Damiati et al., 2016).

However, the increase in energy consumption is not the only problem associated with closed buildings with glazed facades. As a result of the insulation and airtightness of this typology to prevent heat loss or infiltration, overheating and increased humidity inside the spaces can occur, with the dangerous transmission of airborne infections such as Legionella (Martin et al., 2001), in addition to other humidity-related problems such as corrosion, deformations, and the appearance and growth of mold, as shown by studies conducted in Sweden (Berggren, 2013).

The comparison of the behavior of buildings in the United States with air conditioning and others that use hybrid natural ventilation with air recirculation systems, and strategies such as thermal night flushing (Shaviv et al., 2001), showed that it is possible to maintain the space within the setpoint while also achieving energy savings (Ben-David & Waring, 2016). This same comparison in tropical buildings showed the benefits of natural ventilation as an adaptive strategy for comfort with a positive impact on energy savings associated with greenhouse gas emissions (Deuble & de Dear, 2012).

Several researchers have questioned the bioclimatic performance of existing buildings and how this performance will be in the future (Bui et al., 2020; Nieto et al., 2021; Rahif et al., 2017; Velashjerdi Farahani et al., 2022). For example, Joarder et al. (2019) suggest that many buildings that currently operate without mechanical conditioning will depend on air conditioning systems for their operation. Supporting this, Yan et al. (2022) argues that optimal design strategies for existing buildings can vary significantly under different future climate scenarios. According to this, existing buildings will need to be adapted to prevent future increases in energy consumption and greenhouse gas emissions.

Adaptive Thermal Comfort

In natural conditions without mechanical air conditioning systems, it is possible to apply the adaptive thermal comfort model proposed by ASHRAE 2010, which states that thermal comfort sensation in people is associated with personal adaptation strategies. In the Standard 55-2017, it establishes that, in certain circumstances, the limits of thermal comfort ranges can be extended, becoming a central element of climate change policies and research, as an alternative that goes beyond biophysical dimensions (Berrang-Ford et al., 2015).

Studies such as the one by Guarda et al. (2023), propose adaptive comfort ranges for different periods, based on an experimental simulation model in Open Studio + Energy Plus and the modification of climate files, as follows (see Table 5):

Table 5. Adaptive comfort ranges in climate change scenario

Scenario	Adaptive comfort range	Increment in Temperature (°C)	Discomfort hours (Base Case)
Current	22.54 to 29.26 °C		16.6%%
2020 Period	23.01 and 29.84 °C	+ 0.58 °C	66.6%
2050 Period	23.51 and 30.41 °C	+1.15 °C	91.6%
2080 Period	24.41 at 31.25 °C).	+ 5.5 °C,	91.66%

Source: original work from (Guarda et al., 2023)

Additional research supports the relevance of adaptive strategies. For example, Cui et al. (2022), show the benefits of using adaptive ventilation as the key measure to improve thermal comfort to face climate uncertainty. In addition to the positive impact on energy consumption from the implementation of the adaptive model, research developed by Bamdad et al. (2022), has shown how the combination of adaptive comfort strategies, in mixed-mode (MM) ventilation with complementary use of fans in Australian cities, can lead to 23% energy savings under current conditions, while in the future they will only reach 11.5% depending on the analyzed region. Additionally, there is great uncertainty about the future, because under certain climate change scenarios, it may not be possible to adapt to those conditions of certain specific places, especially in extreme events that will happen more frequently.

Based on this model, the NaOR indicator proposes that thermal dissatisfaction should not be anchored to a fixed value of indoor temperature, but to the delta T (ΔT) difference between the indoor operating temperature and the adaptive optimal operating temperature (EN 15251). Therefore, the NaOR seeks to prevent overheating in buildings by controlling other factors such as humidity, air speed, and people's physical activity, and not only by regulating indoor temperature (Carlucci et al., 2021).

Developing Regions

In under-researched regions vulnerable to climate change, studies such as those by Santamouris (2013) and Ali-Toudert & Mayer (2006) highlight urban-scale design strategies to reduce heat islands in warm and tropical climates. Similarly, reports by UN-Habitat (2015) and the IPCC (2022) address the impacts of climate change on informal settlements in tropical regions and propose design recommendations for mitigation.

Fewer studies focus on the architectural scale; among them, Zimring & Nielsen (2019) emphasize the benefits of vernacular strategies for reducing energy consumption, while research by Ogunbode & Molua (2020) in Nigeria demonstrates, through energy simulations under future scenarios, the effectiveness of adaptive design strategies in mitigating climate impacts.

Understanding regional disparities in climate change is essential for developing context-specific adaptation and mitigation strategies that address local vulnerabilities and capacities. This section examines the regional dimensions of climate change, highlighting how environmental transformations are reshaping urban and rural landscapes and testing the resilience of affected communities.

Climate change is expected to intensify the vulnerability of informal settlements in developing regions, where poverty, inequality, and environmental risks intersect. Addressing these challenges requires integrating adaptation and mitigation strategies into slum upgrading efforts, aligning them with Sustainable Development Goals, particularly SDG 11 “Sustainable Cities and Communities” and SDG 13 “Climate Action.” Buildings should incorporate bioclimatic design and renewable energy; transport systems must prioritize low-carbon options; and public spaces should include afforestation and green infrastructure. These integrated approaches not only improve living conditions but also enhance resilience and climate action at the local level (Núñez, Collado & Wang, 2020).

CONCLUSIONS

Integrating the analysis of future bioclimatic performance into the current architectural design process is both urgent and necessary. This approach not only improves the accuracy of building comfort and energy performance assessments but also provides critical insights for making present-day design decisions with long-term implications. The construction of the state of the art of this topic from the review of 101 papers also allows us to conclude that it is essential to consider the risks of designing buildings without accounting for future climate conditions, as well as the need to update tools and technologies to enable more accurate evaluations under various emissions scenarios

Overall, passive design strategies, particularly natural ventilation- have proven to be effective in current scenarios, not only in warm climates. However, there is considerable uncertainty about their effectiveness in achieving thermal comfort and energy savings under future climate scenarios. These findings provide valuable input for the development of public policies, building regulations, and urban planning strategies aimed at addressing climate change.

By incorporating the analysis of future energy demand into the design process and promoting both passive and adaptive strategies, such as natural ventilation and adaptive thermal comfort models, it becomes possible to make informed decisions today that anticipate tomorrow's conditions. The practical application of this evidence requires supportive regulatory frameworks and policy instruments that facilitate its implementation by architects, urban planners, and local authorities. For example, in Colombia, Law 2476 of July 10, 2025, which strengthens climate change adaptation and risk management through green, biodiverse, and resilient cities, exemplifies how national regulations can align with scientific evidence in the pursuit of resilient and sustainable built environments. These experiences offer valuable lessons for facing future climate challenges through a combination of scientific knowledge, regulatory action, and professional practice.

Although the debate over the most appropriate thermal comfort model remains open, the adaptive model stands out as the most suitable approach for defining comfort ranges under climate change scenarios. This model accommodates projected temperature increases while simultaneously supporting energy conservation goals. To ensure its effective implementation, it is crucial to educate both, designers and building users, through applied research and empirical evidence, fostering awareness of the risks posed by climate change and the significant benefits of adopting sustainable and bioclimatic strategies. The integration of legislative support and educational initiatives emerges as a key pathway to facilitate the transition toward a more sustainable and climate-resilient built environment, ultimately contributing to the preservation of livable conditions on the planet.

Finally, the main limitations of this review lie in the inherent uncertainty of climate change projections, which affects the accuracy of future energy performance assessments. Additionally, the available literature is predominantly focused on seasonal climates, which limits the applicability and depth of research in tropical regions. This highlights the need for more context-specific studies that address the unique challenges and opportunities of designing for tropical climates under future climate scenarios.

AUTHORS' NOTE

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Aptis

Candidate report

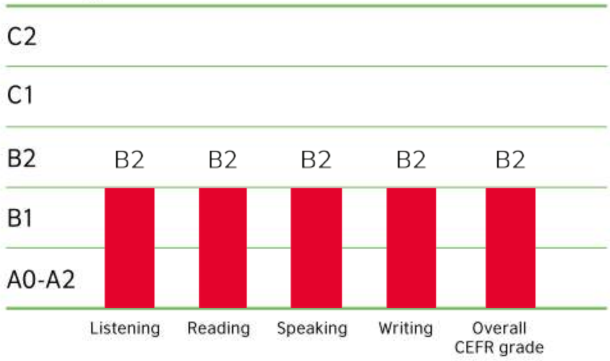
MANUELA MURILLO GALVIS	**03.12.2025**	**Aptis~0714208**
Candidate name	Test date	Enrolment ID
Colombo Americano Medellin	**Aptis Advanced**	
Organisation	Test package	

Scale score

Skill name	Skill score
Listening	30/50
Reading	30/50
Speaking	39/50
Writing	37/50
Final Scale Score	136/200
Grammar and Vocabulary	31/50

CEFR skill profile

CEFR grade



Please turn over for CEFR skill descriptors.

www.britishcouncil.org/aptis

https://credentials.britishcouncil.org/5cd0855d-076a-43ce-a890-b2e6cb4a362e?key=481dd7d0ab3a983d6edd0ede7d2e8878954c5f2d4a7d8b6e72eb5918aacd1327

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CEFR Skill Descriptors

Listening

A0-A2	Candidate's level is below B1.
B1	Can understand straightforward factual information about common everyday or job related topics, identifying both general messages and specific details, provided speech is clearly articulated in a generally familiar accent.
B2	Can understand the main ideas of propositionally and linguistically complex speech on both concrete and abstract topics delivered in a standard dialect, including technical discussions in his/her field of specialisation.
C1	Can understand enough to follow extended speech on abstract and complex topics beyond his/her own field.
C2	Has no difficulty in understanding any kind of spoken language, whether live or broadcast, delivered at fast native speed.

Reading

A0-A2	Candidate's level is below B1.
B1	Can read straightforward factual texts on subjects related to his/her field and interest with a satisfactory level of comprehension.
B2	Can read with a large degree of independence, adapting style and speed of reading to different texts and purposes, and using appropriate reference sources selectively.
C1	Can understand in detail lengthy, complex texts, whether or not they relate to his/her own area of speciality, provided he/she can reread difficult sections.
C2	Can understand and interpret critically virtually all forms of the written language.

Speaking

A0-A2	Candidate's level is below B1.
B1	Can reasonably fluently sustain a straightforward description of one of a variety of subjects within his/her field of interest, presenting it as a linear sequence of points.
B2	Can give clear, systematically developed descriptions and presentations on a wide range of subjects related to his/her field of interest, with appropriate highlighting of significant points, and relevant supporting detail
C1	Can give clear, detailed descriptions and presentations on complex subjects.
C2	Can produce clear, smoothly flowing well-structured speech with an effective logical structure.

Writing

A0-A2	Candidate's level is below B1.
B1	Can write straightforward connected texts on a range of familiar subjects within his field of interest, by linking a series of shorter discrete elements into a linear sequence.
B2	Can write clear, detailed texts on a variety of subjects related to his/her field of interest and shows an ability to use different registers within written texts.
C1	Can write clear, well-structured texts of complex subjects, underlining the relevant salient issues.
C2	Can write clear, smoothly flowing, complex texts in an appropriate and effective style and a logical structure which helps the reader to find significant points.

Universidad Pontificia Bolivariana

Certifica que:

Manuela Murillo Galvis

C.C. 1.152.712.840

Cumplió con
los requisitos exigidos en la

Diplomatura en Educación Virtual

Didáctica y evaluación en AVA   Mi curso virtual   Tutoría y moderación en AVA

Mi Clase en video   Gestión y producción de contenidos educativos digitales

Introducción al diseño instruccional de cursos virtuales   Mi Curso en Brightspace   Mi Clase en podcast

La Diplomatura se alcanza al cumplir una participación de 160 horas entre los diferentes cursos ofrecidos.

Beatriz Elena López Vélez
Directora de Docencia

Luis Andrés Ochoa Duque
Director de UPB Virtual

Vigilada Mineducación

Personería Jurídica
Resolución Nº 1326 del 25 de Marzo de 1975
MINISTERIO DE EDUCACIÓN NACIONAL

VIGILADA MINEDUCACIÓN
Resolución 12220 del 20 de junio de 2016
MINISTERIO DE EDUCACIÓN NACIONAL

Medellín, 01 de diciembre de 2025

LA DIRECTORA DE TALENTO HUMANO

HACE CONSTAR QUE:

La señora **MANUELA MURILLO GALVIS** identificada con cédula de ciudadanía número N° 1.152.712.840, laboró en esta institución desde el 22 de julio de 2024 hasta el 20 de noviembre de 2024, desde el 03 de febrero de 2025 hasta el 08 de junio de 2025, desde el 28 de julio de 2025 hasta el 26 de noviembre de 2025, mediante contratos de trabajo a término fijo inferiores a un año, desempeñándose como Docente de Medio Tiempo en la Facultad de Artes Integradas, dictando las asignaturas detalladas.

PERIODO	ASIGNATURAS / INVESTIGACIÓN / ACADÉMICO-ADMINISTRATIVA	INTENSIDAD HORARIA
Desde el 22 de julio de 2024 hasta el 20 de noviembre de 2024	TALLER DE DISENO VIII	64 horas semestrales
	TALLER DE DISENO VIII	64 horas semestrales
	PRODUCTO DE INVESTIGACION	96 horas semestrales
	PREPARACION CALIFICACION Y ATENCION A ESTUDIANTES PREGRADO	32 horas semestrales
	ASESORIA DE TRABAJOS DE GRADO (PREGRADO)	16 horas semestrales
	ELECTIVA DE POSTGRADOS-EFICIENCIA ENERGÉTICA	48 horas semestrales

PERIODO	ASIGNATURAS / INVESTIGACIÓN / ACADÉMICO-ADMINISTRATIVA	INTENSIDAD HORARIA
Desde el 03 de febrero de 2025 hasta el 08 de junio de 2025	PRODUCTO DE INVESTIGACION	96 horas semestrales
	ASESORIA DE TRABAJOS DE GRADO (PREGRADO)	64 horas semestrales
	PREPARACION CALIFICACION Y ATENCION A ESTUDIANTES PREGRADO	32 horas semestrales
	TALLER DE DISENO VIII	64 horas semestrales
	TALLER DE DISENO VIII	64 horas semestrales

PERIODO	ASIGNATURAS / INVESTIGACIÓN / ACADÉMICO-ADMINISTRATIVA	INTENSIDAD HORARIA
Desde el 28 de julio de 2025 hasta el 26 de noviembre de 2025	TALLER DE DISENO IX	128 horas semestrales
	PRODUCTO DE INVESTIGACION	96 horas semestrales
	PREPARACION CALIFICACION Y ATENCION A ESTUDIANTES PREGRADO	32 horas semestrales
	ASESORIA DE TRABAJOS DE GRADO (PREGRADO)	64 horas semestrales

La presente constancia se expide a solicitud de la interesada.

LILIANA JANET HENAO HINCAPIÉ
Transcriptora: Yudy Patiño Y.