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DEVELOPING SUSTAINABLE ENVIRONMENTAL GUIDELINES FOR COLLECTIONS IN THE TROPICS: A PHILIPPINE CASE STUDY

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ABSTRACT

The extreme heat and humidity in tropical climates challenge the care of collections as they accelerate deterioration, particularly for hygroscopic materials like paintings and works on paper. Their preservation typically relies on energy-intensive climate control systems for storage, handling and exhibition, often contributing an institutions greatest carbon footprint. Amid a global climate crisis and the conservation community's call to reduce energy use, reevaluating temperature and relative humidity (RH) management presents an opportunity to take action. This paper is a study on how environmental guidelines were developed for the Lopez Museum and Library in the Philippines with sustainability in mind. It reviews the institution's previous practices and the collection's environmental history data; assesses impact to collection condition; and identifies environmental needs moving forward, with consideration to object use, institutional programming, and optimum building requirements. The resulting environmental guidelines show that the international practice of maintaining 20±2ºC and 50±5%RH across materials, which had become a standard for many years, is unnecessary for the Lopez Museum and Library collection and sometimes dangerous. It shows how expanding approach from a one-size-fits-all strategy to a material- and context-focused customisation can be safer for the collection, more sustainable, and more energy efficient.

KEYWORDS: preventive conservation, environmental guidelines, climate specifications, tropical climates

1. INTRODUCTION

The Lopez Museum and Library is a small private institution of Philippine history and visual arts. After the end of the colonial period (Spain 1565-1989, America 1898-1946) and the complete destruction of Manila during the Second World War, businessman Eugenio Lopez, Sr. felt there was a dire need for historical continuity and a pathway towards shaping national identity (Lopez, 2009). With devastating losses to museums, libraries and archives, he spent the 1950s acquiring and repatriating thousands of volumes from antiquarian book sellers in Europe and North America that captured the story of the Philippines. This pattern and intensity of collecting would soon expand into other categories, including art.

The collection today spans predominantly the 1500s to present day, comprising mostly rare books, manuscripts, maps, periodicals, photographs, ceramics, Rizaliana, and artworks on paper, canvas and wood. Its exhibition programming actively borrows and commissions contemporary art, taking in a variety of materials in its care. By volume, the collection is mostly hygroscopic, which has always posed a challenge being in a tropical zone (Figure 1) where the extremely hot and extremely humid conditions year-round facilitate deterioration (Maekawa et al, 2015).

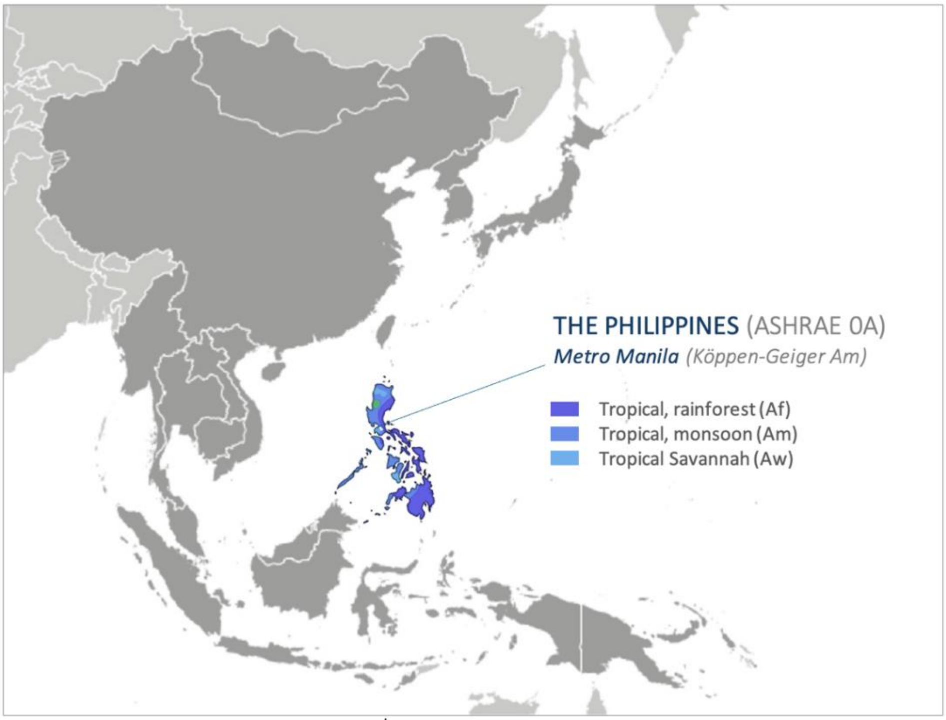

Figure 1. Map of the Philippines in Southeast Asia with Climate Classifications

Deterioration of the collection was first noticed in the 1970s at the original site in Lancaster building by Manila Bay in Pasay City, Metro Manila, where many books and works on paper became noticeably brown, brittle, and warped; paintings became cracked and unstable; and mould was a common occurrence (Servida, 2018). The collection had to be moved inland to Benpres building in Pasig City, Metro Manila in 1986 and eventually given 24-hour indoor climate control.

In the 1990s, climate control was rooted in international practice that became a standard (Taylor and Boersma, 2018) and was centred around a fixed parameter. Maintaining conditions at 20±2ºC and 50±5% relative humidity (RH) was understood to be ideal for material preservation across collections. Being unequipped to meet such conditions, however, Conservation Consultant Ma. Bernardita M. Reyes recommended what she termed "acceptable" parameters at the Lopez Museum and Library, targeting a more sustainable 22±3ºC and 60±5%RH to primarily mitigate mould and wide fluctuations during power interruptions (Reyes, 2018).

In 2018, with the opportunity of relocating to a new building and purpose-built off-site storage facility, I revisited the parameters as Manager of Conservation with the goal of an adjustment from acceptable to ideal, while further optimising sustainability. In the face of a global climate crisis, Chairman of the Board Oscar M. Lopez was a staunch advocate for lowering carbon emissions (OMLC, 2012) and the conservation community had called on museums to reduce energy use (IIC/ICOM-CC, 2014). As climate-control continues to be one of the Lopez Museum and Library's greatest carbon footprint, managing collection temperature and humidity requirements became an important focus.

During the implementation of the design and construction of the off-site storage between 2018-2019 and my participation in the Getty Conservation Institute Managing Collection Environments program 2019-2020, I engaged in a period of research with my colleagues to better understand the history and condition of the collection and developments in the field. Through this period and recent evaluations, the definition of ideal changed. Rather than aiming for international standards originally designed for temperate climate zones (Thomson, 1978), I transitioned to a customised material- and context-focused approach.

In the hope of encouraging localised strategies, I share my process in this paper. I evaluate environmental history data over a 5-year period; assess impact to collection condition in terms of microbial, mechanical and chemical deterioration; and identify environmental needs moving forward, with consideration to object use, institutional programming, and optimum building requirements. The guidelines developed aim to minimize mechanical inputs for climate control without compromising the safety of objects in its care, integrating passive strategies where possible.

2. ENVIRONMENTAL HISTORY

To assess safety, the collection's environmental history was used to provide insight into the acclimatization of the collection and to contextualise its material condition. For hot and humid climates, changes in RH can significantly impact dimensional shifts in hygroscopic supports, consequent mechanical fracture and instability to painted surfaces; and high RH presents risk of microbial activity like mould (Maekawa et al, 2015). High RH and temperature also induce chemical reactions, accelerating the rate of acid hydrolysis particularly in low stability papers, photographs and films, able to damage whole classes of records in a few decades (Michalski, 2000). Identifying the collection's environmental history and its impact to material condition provided a baseline for identifying environmental requirements moving forward.

I collected and analysed the following data:

1. Outdoor climate of Metro Manila, 2013-2017
2. Indoor controls and climate of the Lopez Museum and Library, 2013-2017

2.1 Outdoor Climate

Outdoor climate provided a reference point for demands on environmental controls and assumptions for unmonitored spaces. Data (Tables 1-3) was taken from NAIA, the closest weather station 12km away. From 2013-2017, the monthly mean temperature and RH ranged 22.3-36.3ºC and 61-95% with relatively consistent readings per month as shown by the low standard deviations. The rainy season historically traversed June to November, though with climate change the delineation from dry season is less pronounced with slightly higher deviations in transition months (Table 3).

Table 1. 2013-2017 Monthly and Annual Mean for Minimum Temperature (ºC) in Metro Manila (PAGASA, 2018)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2013	23.3	23.9	24.6	26.5	26.8	26.1	25.3	24.2	24.7	24.8	24.8	24.6	25.0
2014	22.3	22.8	24.1	26.4	27.2	26.4	25.3	25.6	25.2	24.9	24.9	24.2	24.9
2015	22.3	22.7	23.5	25.8	27.0	26.6	25.7	25.6	25.3	25.6	25.4	24.2	25.0
2016	24.5	23.9	25.3	26.9	27.4	26.3	25.7	25.7	25.9	25.8	24.9	24.9	25.6
2017	23.7	23.5	24.3	26.0	27.1	26.2	25.6	26.0	26.0	25.6	25.2	24.5	25.3
Ave	23.2	23.4	24.4	26.3	27.1	26.3	25.5	25.4	25.4	25.3	25.0	24.5	25.2
Std Dev	4%	3%	3%	2%	1%	1%	1%	3%	2%	2%	1%	1%	5%

Table 2. 2013-2017 Monthly and Annual Mean for Maximum Temperature (ºC) in Metro Manila (PAGASA, 2018)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2013	30.1	31.9	32.7	35.4	34.6	33.5	32.2	30.5	30.3	30.5	31.5	31.2	32.0
2014	29.6	31.2	32.7	34.9	36.3	32.5	31.0	31.3	31.0	31.8	31.8	30.0	32.0
2015	29.6	30.7	32.3	34.6	35.1	34.6	31.7	31.8	32.4	31.8	33.2	31.5	32.4
2016	31.8	31.6	33.6	35.6	35.5	33.5	33.1	31.4	31.9	32.2	31.8	31.6	32.8
2017	30.4	30.7	32.8	34.3	34.9	33.9	32.4	32.4	32.4	31.5	32.2	30.7	32.4
Ave	30.3	31.2	32.8	35.0	35.3	33.6	32.1	31.5	31.6	31.6	32.1	31.0	32.3
Std Dev	3%	2%	2%	1%	2%	2%	2%	2%	3%	2%	2%	2%	5%

Table 3. 2013-2017 Monthly and Annual Mean for Relative Humidity (%) in Metro Manila (PAGASA, 2018)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2013	72	69	67	63	71	77	80	84	89	79	79	79	76
2014	66	67	65	61	62	80	88	86	86	81	76	77	75
2015	72	67	64	62	66	69	79	82	85	80	70	75	73
2016	71	68	65	61	68	80	81	91	89	84	80	78	76
2017	75	71	67	68	73	80	86	85	88	95	84	84	80
Ave	71	68	66	63	68	77	83	86	87	84	78	79	76
Std Dev	4%	3%	2%	5%	6%	6%	5%	3%	2%	8%	6%	4%	11%

2.2 Indoor Controls and Climate

Inside the Benpres building, the climate was controlled by a poured concrete building envelope and 24-hour mechanical support through alternating air-conditioning units plus centralised air-conditioning Monday to Friday, 7am to 5pm, and dehumidifiers Monday-Saturday, 8am-5pm (Figure 2). Dehumidifiers were portable refrigerant models. A portion of the books, manuscripts and periodicals were stored within glass and wood cabinets, some containing desiccants.

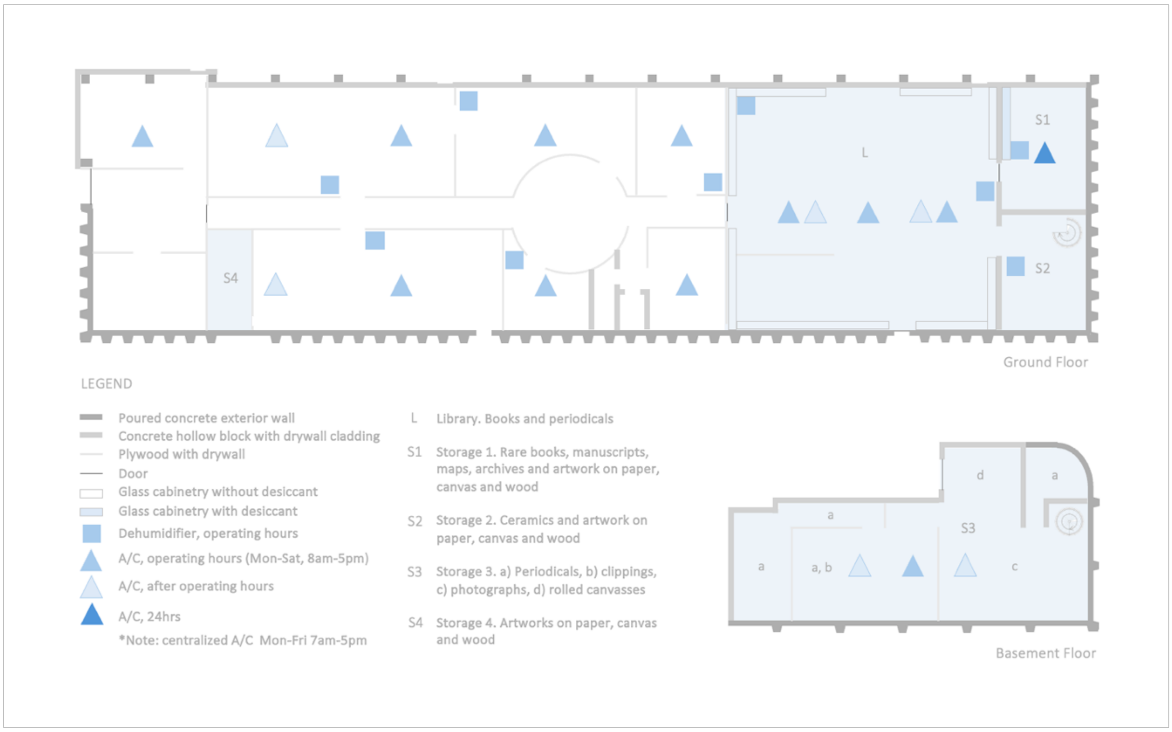

Figure 2. 2013-2017 Climate Controls at the Benpres building with predominant materials per area

Data was collected by measuring temperature and RH with a handheld ELSEC 774 Environmental Monitor with accuracy of ±0.5ºC and ±2.5% (ELSEC, 2018) that was calibrated annually. Measurements were taken once in the morning, once in the afternoon and manually recorded. Information was also gathered from staff interviews for cabinets that contained digital hygrometers whose measurements were not recorded. No measurements were taken outside operating hours.

The 2013-2017 data for collection areas in long term storage and display shows that the entire collection has been historically exposed to very similar environmental conditions that are relatively consistent regardless of time of day or season (Table 4), with the exception of rare books, manuscripts and Rizaliana kept in glass and wood cabinets with desiccants.

The historical average temperature is the same at 23.1±0.8ºC. The narrow standard deviation suggests the air conditioning functions precisely during operating hours when both the centralized and independent units are turned on (Figure 2). Outside operating hours, it is possible temperature slightly increases and has a broader fluctuation, though is unlikely to exceed 25ºC, the average minimum value of the external climate (Table 1), as operating hours are within 1.5 hours of sunrise and 1 hour of sunset. Thus, the targeted 22±3ºC is maintained (Figure 3).

Table 4. 2013-2017 Indoor Climate Data – Temperature (T) and Relative Humidity (RH) at Benpres Building

2013-2017		LIBRARY		STORAGE 1		STORAGE 2		STORAGE 3		STORAGE 4		ALL	
Time of day		T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)
AM	**Ave**	**23.1**	**72.9**	**23.1**	**70.6**	**23.1**	**71.4**	**23.1**	**71.5**	**23.0**	**72.9**	**23.1**	**71.9**
	Std Dev	0.8	2.9	0.8	2.6	0.7	3.0	0.8	2.8	0.5	3.9	0.8	3.0
	Max	25.6	80.5	25.8	77.5	27.0	78.6	25.6	79.8	24.1	79.1	27.0	80.5
	Min	20.5	64.1	21.0	63.9	20.5	73.6	20.2	60.6	21.6	64.5	20.2	60.6
	Count	1,203	1,205	535	535	586	587	877	879	22	22	3,223	3,228
PM	**Ave**	**23.0**	**70.8**	**23.1**	**68.5**	**23.0**	**69.9**	**23.0**	**69.8**	**23.2**	**72.0**	**23.0**	**69.9**
	Std Dev	0.8	3.2	0.8	2.7	0.8	2.9	0.8	2.5	0.7	3.0	0.8	3.0
	Max	25.6	78.2	28.2	76.3	25.3	77.9	25.6	78.1	24.6	77.3	28.2	78.2
	Min	20.6	60.8	21.1	62.2	20.7	61.4	21.0	59.8	22.1	65.0	20.6	59.8
	Count	689	688	351	351	382	382	523	522	11	11	1,956	1,954
Season		T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)
Rainy	**Ave**	**23.0**	**72.8**	**23.0**	**70.7**	**23.0**	**71.6**	**23.0**	**71.3**	**23.1**	**72.6**	**23.0**	**71.8**
(Jun-Nov)	Std Dev	0.8	3.1	0.7	2.3	0.8	2.8	0.8	2.8	0.6	3.6	0.8	2.9
	Max	25.6	80.5	25.8	76.7	27.0	78.6	25.6	79.8	24.6	79.1	27.0	80.5
	Min	20.6	60.8	21.0	62.6	20.9	62.8	20.7	60.6	21.6	64.5	20.6	60.6
	Count	1,027	1,028	488	488	534	535	696	697	33	33	2,778	2,781
Dry	**Ave**	**23.1**	**71.3**	**23.2**	**68.7**	**23.1**	**69.8**	**23.1**	**70.4**			**23.1**	**70.3**
(Dec-May)	Std Dev	0.8	3.1	0.8	2.8	0.7	3.0	0.8	2.8			0.8	3.1
	Max	25.5	79.0	28.2	77.5	25.3	78.4	25.5	78.0			28.2	79.0
	Min	20.5	61.0	21.2	62.2	20.5	61.4	20.2	59.8			20.2	59.8
	Count	865	865	398	398	434	434	704	704	0	0	2,401	2,401
Year		T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)	T (ºC)	RH (%)
Jan-Dec	**Ave**	**23.1**	**72.1**	**23.1**	**69.8**	**23.1**	**70.8**	**23.1**	**70.8**	**23.1**	**72.6**	**23.1**	**71.1**
	Std Dev	0.8	3.2	0.8	2.8	0.8	3.0	0.8	2.8	0.6	3.6	0.8	3.1
	Max	25.6	80.5	28.2	77.5	27.0	78.6	25.6	79.8	24.6	79.1	28.2	80.5
	P97.5	24.6	77.4	24.6	74.7	24.6	76.4	24.9	76.1	24.2	78.4	24.7	76.9
	Min	20.5	60.8	21.0	62.2	20.5	61.4	20.2	59.8	21.6	64.5	20.2	59.8
	Count	1,892	1,893	886	886	968	969	1,400	1,401	33	33	5,179	5,182

The historical average RH is 71.1±3.1% (Table 4), 11.1% higher than the targeted 60±5%RH (Figure 3). The histogram (Figure 4) provides a more detailed statistical view, illustrating how often the collection is exposed per RH. Storage 1-3 mostly coincide, with peak frequency ranging 69-73%RH, and the library slightly higher and broader ranging 70-76%RH. The histogram also shows significant frequency in the high-risk germination zone above 75%RH for fungal and bacterial spores. 97.5 percentile of data is used to determine maximum RH exposures while excluding short and unharmful excursions (Maekawa et al, 2015). The maximums for library and storage 1-3 are in the germination zone at 77.4%RH, 76.4%RH and 76.1%RH respectively.

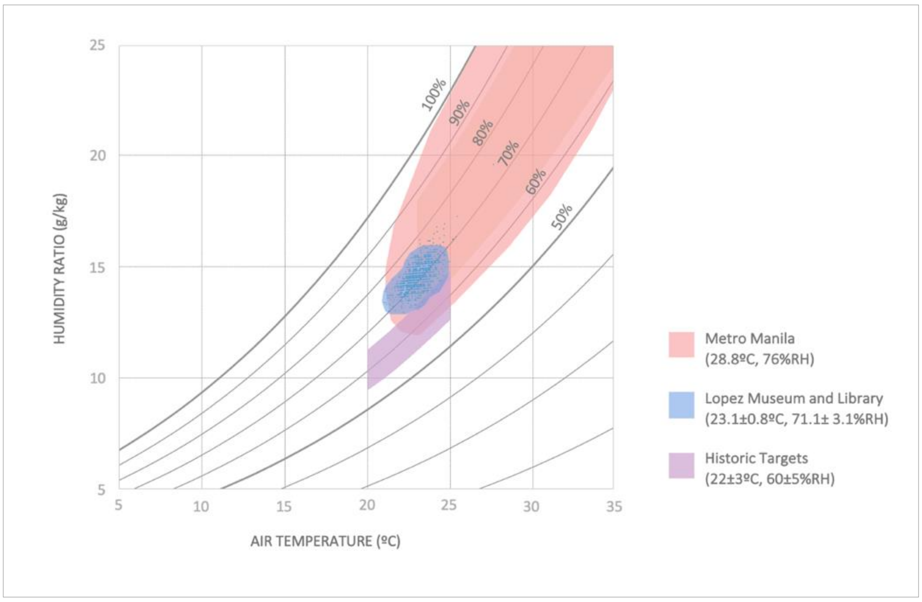

Figure 3. 2013-2017 Indoor Climate compared to Outdoor Metro Manila and Historic Targets

Data for Storage 4 is limited in count and potentially inaccurate. Conditions are likely higher than the 72.6%RH recorded as the room is enclosed without air-conditioning. Data may be attributed to cooler and drier air entering from the gallery when the door is opened to take measurements.

Cabinets without desiccants were likely similar in RH to the rooms, as cabinets were not airtight. Cabinets were opened at least once a year for general cleaning. For cabinets with desiccants, RH was mostly maintained between 55-60%RH (Servida, 2018). 600g of calcium chloride-based desiccant developed by Hippo Moisture Absorber was used per cabinet, each approximately 0.25m^3. Librarians were tasked to replace the desiccant when readings reached 60%RH (Servida, 2018; Reyes, 2018).

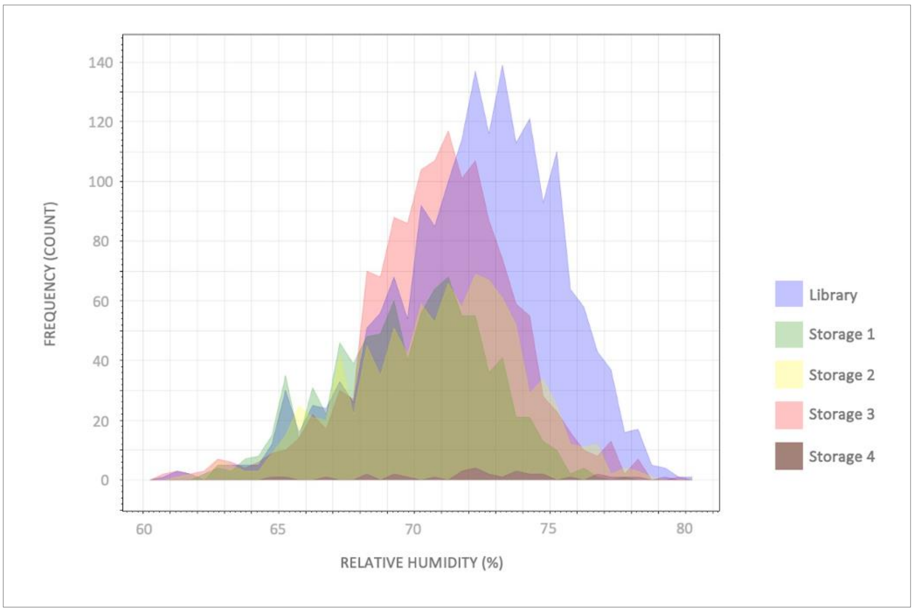

Figure 4. 2013-2017 Frequency of Relative Humidity Level per Collection Area

3. CONDITION OF THE COLLECTION

The condition of the collection is consistent with the implications of its environmental history to microbial, mechanical and chemical deterioration. Mould occurred regularly, except for inside desiccated cabinets. According to interviews, mould was detected in the library during annual cleaning, particularly inside non-desiccated cabinets, and in Storage 3 during heavy rains. For Storage 1, 2 and 4, materials with mould were sent to conservation for fumigation. According to 2013-2017 records, 252 objects were fumigated in the 5-year period, varying from 17 to 86 in one year. Detection was by circumstance when noticed by librarians or requested by researchers and curators, so it is possible more objects had mould undetected.

For mechanical damage, distortions to supports for books, works on paper, canvas and wood and instability to painted surfaces were not apparent by observation. Where available, comparisons to images taken in previous years showed no visible change. Out of the 160 artworks examined upon fumigation between 2013-2017, only 7 required treatment for unstable paint. This is consistent with the narrow historical RH fluctuations of ±3.1% as Δ0≤xΔ10%RH presents no risk to mechanical damage (Maekawa et al, 2015).

Table 5. Material types in each stability category (adapted from Michalski, 2000)

HIGH CHEMICAL STABILITY	MEDIUM CHEMICAL STABILITY	LOW CHEMICAL STABILITY
Lifetime 300-1000 years at 20ºC/50%RH	Lifetime 100-300 years at 20ºC/50%RH	Lifetime 30-100 years at 20ºC/50%RH
Parchment, velum. Rag paper, not acidified by pollution or sizing. Alkaline paper. Wood. Most black-and-white (silver/gelatin) photographs or microfiche (on paper, glass, or polyester). Most collodion negatives on glass. Paint on wood, canvas, or stable paper.	Mildly acidic papers (most papers and boards). Most black-and-white (silver/gelatin) negatives and films on acetate and nitrate. Albumen photographs. Some collodion glass negatives. Some colour photographs on paper, on film. Well-made optical digital media (CDs).	Strongly acidic paper (e.g. acidic newsprint or paper and leather exposed in the past to acidic pollution). Poorly processed photographs. Most colour photographs. Some acetate and some cellulose nitrate film (and negatives). Magnetic media (e.g. video, digital tapes, disks)

For chemical deterioration, brown discoloration and brittleness associated with acid hydrolysis were noticeable in early 20th century book papers in the library; 16th to 19th century book papers, maps, ephemera, and canvases in Storage 1; and 20th-21st century newsprints in Storage 3, which also emitted an odour. De-acidification treatments and associated structural repairs are part of the regular conservation programming. Black and white photographs did not noticeably change compared to previous documentation, while coloured photographs had some fading and microfilms succumbed to vinegar syndrome. Studies show that materials with hydrolysis-dominated deterioration can be classified into three categories: high- medium- and low- stability, each with a projected lifetime given a 20ºC and 50%RH equilibrium (Table 5). Exposure to the historic 23.1±0.8ºC and 71.1±3.1%reduces material lifetime to 42% (Figure 5). In theory, canvases and objects comprising vellum, parchment and rag paper in Storage 1 and black and white photographs in Storage 3 characterized as high chemical stability have a reduced lifetime of approximately 126-420 years (Figure 5). Mildly acidic papers which characterize majority of library and Storage 1 materials have medium stability and a lifetime of approximately 42-126 years, and strongly acidic papers which characterize some materials in Storage 1, newsprints in Storage 3, most coloured photographs, and microfilms have a lifetime of 13-42 years. While the 30-year-old microfilms have indeed perished, some 100-year-old newsprints can still be delicately handled suggesting that, with an equilibrium at higher conditions, the quantification in years may change. The relative rate of deterioration, however, likely persists.

4. PROGRAMMING AND USE

With a vision of greater access and engagement, the Lopez Museum and Library was relocated from Benpres building in 2019 to the purpose-built off-site storage facility, from which select works will be exhibited on rotation in 2026 at a new museum in Rockwell Makati. Rockwell is a pocket community strategically located between Metro Manila's central business districts. Exhibition programming will continue to include contemporary art commissions and domestic loans displayed alongside permanent collection works and will expand into international loans. Facility requirements for environmental management between both sites consider collection needs in long term storage, exhibition, and collection handling zones, international loan protocols at 40-60%RH (Bizot 2015), and domestic loans acclimatized to non-airconditioned spaces with RH exceeding 75%.

5. INTEGRATING SUSTAINABILITY

The varying needs of the collection and programming challenge the one size fits all approach to environmental management, especially in the context of energy savings. Traditionally, the most vulnerable materials set the collection parameter. In the case of the Lopez Museum and Library, these would be the newsprints with a life expectancy of 13-42 years. An adjustment from 23.1±0.8ºC and 71.1±3.1% to the historical international standard at 20±2ºC and 50±5% would increase lifetime by about x2.4 (Figure 5) while mitigating microbial growth. The >20%RH difference, though, from the historical mean would present high risk of mechanical damage to painted surfaces (Maekawa et al, 2015) for collections and domestic loans. Moreover, the energy cost would be considerable. In the Philippines, dehumidifying conditions to 50%RH versus 60%RH requires a different category of machinery that is more energy intensive and risky at times of mechanical failure and maintenance where RH can spike. Plus achieving 50%RH is not always necessary, as in the case of the Lopez Museum and Library, where 50%RH can even be dangerous.

While one-size strategies may appear simple, their execution is complex and may not meet objectives. Shifting strategy to customisation, though still complex, may be safer for collections and loans, and more energy efficient. For the Lopez Museum and Library, important environmental thresholds are <70%RH to avoid moderate risk of mould (Maekawa et al, 2015) and >60%RH as much as possible, to avoid more energy-intensive machinery. The paintings and artworks on paper are safe in this range. They have high chemical stability and are acclimatised to 73.1%RH. At a 65±5%RH environment, where the absolute difference from historical mean is <10% and fluctuations do not exceed 10%RH within a 24-hour period, there is no risk of mechanical damage. Temperature can be maintained at 23±2ºC, the upper limit for stability in paint films. These set points can be used for majority of spaces, namely dedicated artwork storage, handling zones, exhibition galleries and temporary storage. In the case of incoming international loans, volumetric space can be limited to a designated gallery equipped to achieve the 50-60%RH of Bizot, though set to 65±5%RH until needed.

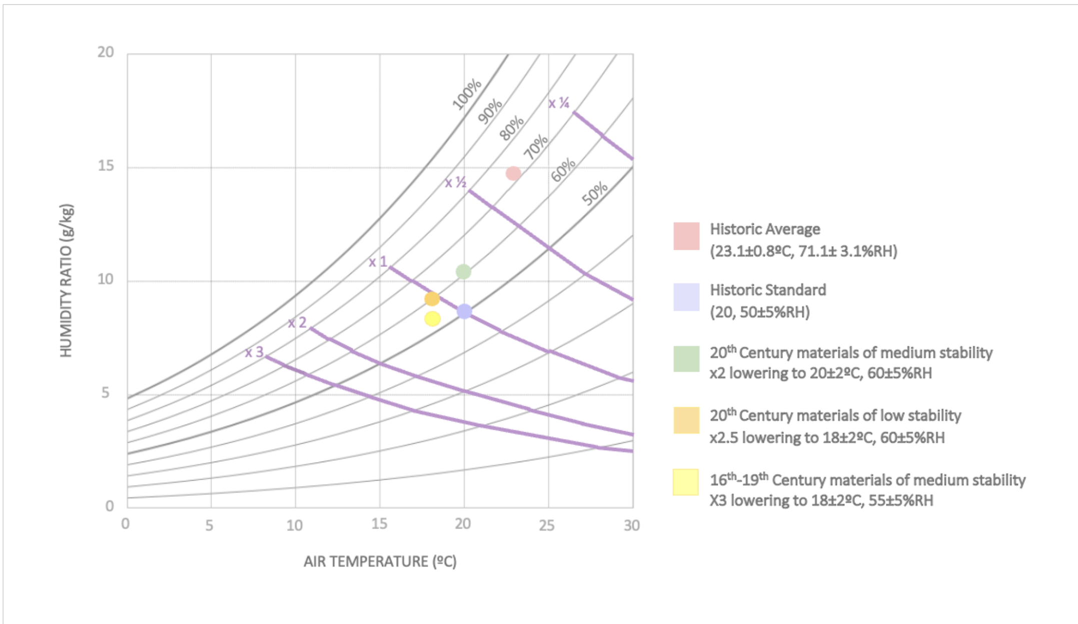

Figure 5. Targets for low- and medium- chemical stability materials relative to lifetime multiplier for collections with hydrolysis-dominated deterioration (adapted from Michalski, 2000)

For chemical deterioration, where lifetime is measured in centuries, short periods in handling zones or exhibitions exposed to 23±2ºC and 65±5%RH can be tolerated and passive object-level interventions (e.g. microclimate displays) for low stability materials can be accommodated as needed to avoid adjusting rooms. Lower set points can be limited to long-term storage spaces and adjustments focused on temperature, as a 5ºC drop has the same effect in doubling lifetime as an RH drop from 80% to 50% at 20ºC (Figure 5) and requires less energy. With the goal of the collection surviving about 100 years more, the Library with 20th century medium stability materials is set to 20±2ºC and 60±5%RH to extend lifetime by a factor of about x2; Storage 3 with 20th century low stability materials to 18±2ºC and 60±5%RH to extend by about x2.5; and Storage 1 with 16th-19th medium stability materials to 18±2ºC and 55±5% to extend by about x3 (Figure 5). With greater mechanical requirements in Storage 1, the volumetric space is reduced by separating artworks. Microfilm duplicates continue to be outsourced to a film storage facility.

Of note are outgoing loans. Customisation of environmental guidelines often leads to gaps between conditions of the borrower and the lender. Considerations and negotiations in loan agreements would need to be case-to-case (Villanueva et al 2023). Also, in designing new facilities, opting for energy-saving mechanical systems (e.g. inverter air-conditioning, desiccant dehumidifiers, etc.), renewable energy sources (e.g. solar, etc.) and optimising building envelope and air tightness can further lower carbon footprint (ASHRAE 2019).

6. CONCLUSION

The case of the Lopez Museum and Library shows that for hot and humid climates, strategically customising environmental requirements and veering away from defacto historical standards present an opportunity for safer and more energy efficient indoor climate control. The ideal conditions for the Lopez Museum and Library in an age of sustainability are not the single set point of 20±2ºC and 50±5%RH, but the varied set-points in Table 6 that consider each material's environmental history and condition as well as institutional programming.

Table 6. Lopez Museum and Library Environmental Guidelines

LOPEZ MUSEUM AND LIBRARY ENVIRONMENTAL GUIDELINES 2025		
Collection Area	Temperature (T)	Relative Humidity (RH)
Storage 1 (Artwork)	23±2ºC	65±5%
Storage 2 (16th-19th Century books, maps, manuscripts, Rizaliana)	18±2ºC	55±5%
Storage 3 (20th-21st Century books)	20±2ºC	60±5%
Storage 4 (20th-21st Century periodicals, clippings, photographs)	18±2ºC	60±5%
Storage 5 (Objects)	23±2ºC	65±5%
Temporary storages	23±2ºC	65±5%
Galleries	23±2ºC	65±5%
International Gallery	23±2ºC	55±5%
Collection handling zones	23±2ºC	65±5%

Provisions
- Low risk of microbial activity 65<x≤70%RH with no air movement. Extra precautions needed during rainy season
- T and RH of collection areas and external environment to be logged continuously at 15min intervals
- Conservation and Collections Management to be alerted for fluctuations outside the recommended ranges
- Conservation to be consulted for incoming and outgoing loan, transit, and exhibition requirements
- Passive strategies (e.g. microclimate displays to be considered before lowering T and RH in galleries
- Guidelines to be reevaluated after 5 years

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REFERENCES

ASHRAE. (2019) A24 - Museums, galleries, archives and libraries. In American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook - HVAC Applications (pp. 24.1-24.46).

Atlanta, GA: ASHRAEBizot Group (2015) Bizot Green Protocol, Environmental Sustainability: Reducing Museums' Carbon Footprint, National Museum Directors' Council: London.

IIC/ICOM-CC. (2014) *Declaration on Environmental Guidelines*. Retrieved from International Institute for Conservation of Historic and Artistic Works: https://www.iiconservation.org/archives/about/policy-statements/environmental-guidelines

Littlemore Scientific (2018) *Environmental Monitors*. Retrieved from ELSEC: https://www.elsec.com/collections/environmental-monitors

Lopez, O. M. (2009) Preface. In J. Cruz, E. Legaspi-Ramirez, S. D. Quiason, and F. Sta. Maria, *Unfolding Half a Century: the Lopez Memorial Museum and Library (pp. 8-9).* Pasig: Eugenio Lopez Foundation, Inc.

Maekawa, S., Beltran, V., and Henry, M. C. (2015) *Environmental Management for Collections.* Los Angeles: The Getty Conservation Institute.

Michalski, S. (2000) Guidelines for Humidity and Temperature for Canadian Archives. *CCI Technical Bulletin*, 23.

Oscar M. Lopez Center (2012) *About us*. Retrieved from Oscar M. Lopez Center – Science for Climate Resilient Communities: https://www.omlopezcenter.org/about/

PAGASA (2018). 2013-2017 Climate Data at NAIA (MIA) Pasay City. Quezon City: Department of Science and Technology - Philippine Atmospheric, Geophysical and Astronomical Services Administration.

Reyes, M. (2018, June 14) Conservation Consultant (M. Villanueva, Interviewer)

Servida, M. (2018, June 14) Head Librarian (M. Villanueva, Interviewer)

Taylor, J. and Boersma, F. (2018) Managing Environments for Collections: The impact of International Loans on Sustainable Climate Strategies. *Studies in Conservation*, 63 (NO. S1), 257-261.

Thomson, G. (1978). *The Museum Environment*. London: Butterworth.

Villanueva, M., Páez Cure, A., & Brokerhof, A. W. (2023) A climate balancing act: negotiating environmental conditions for loans between different climate zones. In J. Bridgland (Ed.), *Working Towards a Sustainable Past. ICOM-CC 20th Triennial Conference Preprints, Valencia, 18-22 September 2023*. Paris: International Council of Museums.