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Lighting energy efficiency in Museums; A case of comparison between museums of Nepal

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Abstract
Lighting energy efficiency refers to the optimum use of lighting energy for the same task without affecting the performance. Implementing energy efficient measures across various domains holds the potential to conserve a significant amount of energy while maintaining desired outcomes. Museums being spaces dedicated to the preservation and display of the historically significant artifacts, require controlled thermal and lighting environments to ensure the longevity of the artifacts. The objective of this research is to assess whether museums have implemented suitable lighting illumination levels and strategies or not. The research started with the identification of research gap in field of energy efficiency. A comparative study between three museums of Nepal namely Namuna Ghar of Bhaktapur, National Museum of Nepal, Chhauni and Military Museum, Chhauni has been done. Manual measurement of the illumination levels of each artifacts with the help of lux meter was done and then comparison of the values with the standard literature data obtained from the literature review was done. Open ended interview has also been done with the staff members in the museum. The results which have been obtained clearly states that lighting measures have not been a matter of focus in Nepalese Museums. The lighting illuminations are found to be insufficient in some places and excessively illuminated in other places which urges a need to revisit the lighting provisions in Museums of Nepal. This research presents an opportunity to enhance the lighting efficiency within museums for the proper conservation of the artifacts for a longer time.

Keywords
Energy, Efficiency, Lighting, Illumination level, Museum, Conservation, Artifacts

1. Introduction

Lighting plays a crucial role in establishing a meaningful connection between people and museum artifacts within a designated space. It is a pivotal element in the museum environment as it allows visitors to observe objects, encounter novel visuals, and respond to the surrounding atmosphere. Lighting also plays a role in creating ambiance around the space and create a sense of comfort among the visitors. This creates a sense of storytelling and interpretation in the museum as well. Another aspect of lighting in museum is also to ensure the safety and easy accessibility of visitors.

Energy being a crucial part of lives should be used efficiently so that the future generations to come can use it as well. Energy retrofits possess the capacity to lower energy usage and decrease carbon emissions in buildings, but encounter specific difficulties when applied to historically and conventionally constructed structures [1]. In the realm of sustainable development and the preservation of energy, energy auditing is a vital and irreplaceable factor. An energy audit is a comprehensive examination that aids in identifying energy consumption across various services and offers insights into potential energy-saving opportunities [2]. Energy auditing involves systematically identifying areas within a system where the input of energy can be decreased without negatively impacting the output. Identification of opportunities to reduce carbon footprints and energy costs is the major step of energy audit process. An energy audit assesses the energy consumption of a space and subsequently devises a strategy to enhance energy efficiency by reducing energy usage [2]. The energy consumption is also influenced by architectural design and maintenance practices, which are further compounded by the usage patterns of devices. Lighting and thermal aspects in a museum play a crucial role in energy consumption patterns [2].

Museums are spaces for the protection as well as proper display of the artwork collections [3]. In case of museums, we ought to be careful to what extent are we illuminating the artifacts. It is because only the standard illumination of light to the artifacts can ensure the longevity of the artifacts holding a historical value. Although the light is an essential component in museum, the non-impactful use of light can have negative impact on the artifacts. Illumination in museums if provided in inadequate amount, the visitor will not have the visual comfort. As well as this, the visitor will be unable to appreciate the artwork if not seen clearly as well. In contrast, if the illumination is provided in an excessive amount, the piece of artwork can undergo degradation through two processes namely, the photochemical effect and the radiant heating effect. The harsh intensity of light and the constant heating effect the light gives can be harmful to the artworks leading to shorten the lifespan and lead to gradual loss of the historical valued artifacts which is not the sole purpose of the museum. Natural light, despite its significant brightness, emits abundant Ultraviolet rays, which are recognized for their capacity to harm textiles and artifacts. [4].

In case of Nepal, most of the museums are housed in traditional buildings which is a case of adaptive reuse. Adaptive reuse is an appreciative approach of conservation but may also act as an energy intensive space. There is no

such rules or guidelines in Nepal for the lighting layout or the illumination levels according to the different types of artifacts whereas the fact is that different types of materials being based on their level of sensitivity require different level of illumination. Even the staffs appointed at the museums who come from the archaeological background seem to be unaware of the scenario. Those few ones who know about this seem to be lacking in implementing the need due to the administrative mess they have to go through just to pass the bill. It was a bit shocking to me when the staffs said to me, "We did not know how to measure the lighting intensity and there was this existence of lux meter in Nepal as well." So, this is a huge research gap to me, the area where research need to be done to check if the illumination levels of artifacts are done as per their standards or not. The statement also led me an interest to investigate if energy can be saved up because to conserve energy is to produce energy. Comparative study research has been implied in this research. The study started with the intensive literature reviews related to lightings in museums followed by site visit and data analysis. Lux meter has been used in each and every artifact to measure their illumination standards and then compared with the illumination standards. The electrical consumption survey has also been done to calculate the areas for energy conservation. By the end of this research, there will a clear vision on the illumination levels of museums in Nepal and if they are appropriate or not. Ways to fix the problem if necessary will also be found. Also, a set of guidelines can be made out of this research for implementing in new futuristic museums for the conservation and longevity of the art works. This way, this research will be highly valuable for the government and the concerned bodies of the museum for saving up the energy consumption and eventually the bills.

2. Literature Review

2.1 Lighting energy efficiency in Nepal; A historical brief

Although various plans and strategies have been developed in paper for the energy efficiency strategy of Nepal, not much have been actually implemented. If the works had been implemented as in the papers, Nepal would have been much ahead in the field of energy. According to Energypedia [5], "To date, there is no "National Energy Strategy" for Nepal". On the top of this, no guidelines or strategies specified for a certain space has been made and so is not available for the museums. Looking back to the history of energy efficiency, the study and introduction to energy efficiency seem to be have initiated back in 1985 A.D [6]. Yet, not much have been done in the field of energy efficiency. It may be because we are relying on only a major source of energy which is the hydropower. Various trainings related to energy efficiency and the programs like replacement of traditional lamps with C.F.L. and then to L.E.D. lights have been done but no one has ever checked upon the accuracy of the illumination levels in the artifacts of the museums which are of high value and can degrade if neglected. Table 1 shows the chronological development in the field of energy efficiency and the major developments and initiatives in the field of energy efficiency.

Table 1: Table showing the chronological development of energy efficiency in Nepal

SN	Fiscal year (A.D.)	Initiatives
1	1985	Inception of study and analysis of EE occurred.
2	1999-2005	Energy auditing of the commercial sector, trainings, awareness programs on EE, loan management for EE in industrial sector were done.
3	2009-2011	GoV launched and implemented Nepal Energy Efficiency Programme(NEEP), energy audits and related policies were initiated, replacement of inefficient lights with the efficient ones were done.

Various action plans were also developed in the field of energy efficiency in Nepal. The latest action plan developed in Nepal regarding the energy efficiency is the National Energy Efficiency Strategy 2075. The action plans in this strategy [7] are:

1. **Generate Awareness on Energy Efficiency**:
   - Conduct public awareness campaigns for the residential sector.
   - Implement programs for industrial, commercial, and transport sectors.
   - Conduct programs for farmers on energy-efficient equipment.
   - Incorporate energy efficiency into educational curricula.
   - Conduct programs in public and community organizations.
2. **Establish Policy, Legal, and Institutional Frameworks:**
   - Designate an energy efficiency entity.
   - Strengthen existing energy efficiency cells and expand to relevant ministries.
   - Conduct research on energy efficiency and demand-side management.
   - Develop a system for the commercialization and market expansion of energy-efficient technologies.
3. **Develop National Standards for Energy Efficiency:**
   - Conduct studies and energy audits to identify energy-saving measures.
   - Promote the use of energy-efficient equipment in transport and industrial sectors.
   - Determine energy efficiency standards and labels for equipment.
   - Ensure human resource development for the production, commercialization, and technology transfer of energy-efficient goods and services.

4. **Make Services and Production Cost-Effective:**
    - Institutionalize energy efficiency through the development of a National Energy Efficiency Action Plan.
    - Identify large-scale electricity consumers and conduct energy audits.
    - Prepare necessary human resources for energy audits through training.
    - Develop minimum energy performance standards for electrical and mechanical equipment.
    - Conduct various programs for energy audits in industrial, commercial, and public sectors.
5. **Reduce Energy Import by Energy Conservation:**
    - Reduce energy imports by utilizing energy saved through efficiency.
    - Conduct studies and research on reducing peak demand and implement demand-side management programs.

2.2 Required illumination levels in different types of artifacts

While discussing about required illumination levels in different types of artifacts, research related to lighting energy efficiency in case of museums have been done in other countries. Some of the papers have discussed about the illumination levels whereas others have discussed the characteristics of lighting required for a museum.

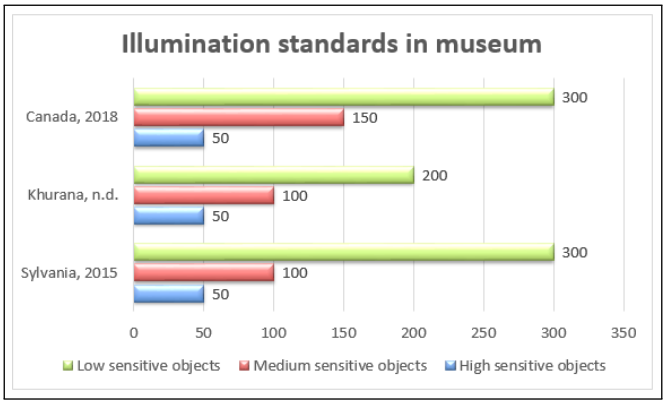

Figure 1: Chart showing the comparative data for illumination of different materials [8, 9, 10]

The minimum value of illumination needs to be 50 lux for proper visibility of objects [8]. This minimum value will provide us the visual comfort but for the preservation of the different types of artifacts in the museum, depending upon how sensitive the material is to light intensity, the values are different. Figure 1 above depicts that the illumination on highly sensitive objects like costumes, textiles, fur, feathers, manuscripts, canvas etc. needs to be subjected only at an illumination of 50 lux. Similarly, the medium sensitive objects like wood, bones, plastics, horn, etc. needs to be illuminated at a range of 100-150 lux. Also, the comparatively low sensitive objects like stone, ceramics, glass, metals etc. needs to be illuminated on a range of 300 lux.

2.3 Need for conservation of objects and proper museum lighting efficiency

Optimizing the lighting in museums is a vital consideration when designing lighting systems. The goal is to ensure that artworks are well-illuminated for clear visibility while simultaneously reducing energy usage and the risk of harming delicate artifacts. According to C.Cuttle [11], damage to museum objects due to light exposure occurs due to two processes:

- Photochemical action
- Radiant heating effect

Modern approaches to museum lighting seek to find a delicate equilibrium between two primary objectives: reducing the potential harm caused by light to artworks and achieving the most visually appealing presentation through lighting [11]. Light holds the potential to inflict gradual damage upon delicate materials, such as fading pigments and the degradation of organic substances, over prolonged periods. In the pursuit of efficient lighting designs, a paramount objective is to curtail the exposure of artworks to excessive light and the detrimental effects of ultraviolet (UV) radiation. A prudent approach encompasses strategies aimed at minimizing artifact light exposure. Exhibition layouts must be meticulously devised to mitigate UV light impact. The selection of light sources becomes pivotal in this endeavor, favoring those that refrain from emitting UV rays. Employing motion sensors emerges as an ingenious solution, ensuring that illumination is activated solely in the presence of visitors. This serves to safeguard artworks by reducing their exposure to light when unoccupied. Furthermore, corridors, often overlooked, can also contribute to energy efficiency. The integration of sensor-based lighting systems in corridors stands to achieve dual benefits. Not only does it conserve energy by illuminating only when required, but it also maintains the desired illuminance levels, ensuring visitor safety and comfort. In summary, efficient lighting strategies warrant a comprehensive approach to safeguard artworks from the deleterious effects of light exposure. By embracing prudent design choices, including UV-minimizing sources, motion sensors, and corridor-based sensors, museums can uphold their preservation responsibilities while also promoting energy conservation.

3. Methodology

This research uses quantitative approach to analyse the level of energy efficiency in museums of Nepal. Individual investigation of lighting levels in each museums has been implied in this research carrying three different museums of historical importance. The museums have been chosen on the basis of material of the artifacts displayed . Also, the scale of the museum has also been considered from small scale to the national scale.

The research started with the identification of research gap in field of energy efficiency. The research schedule was made for the list of works to be done and was followed accordingly. An intensive literature review was done. Under this section, data

like the types of lighting, types of luminaires, what standards should be followed in a museum, the need for comfortable museum, need for conservation of artifacts and proper illumination level etc. were studied. As an outcome of this study, a list of standard data of illumination level actually required to illuminate different types of artifacts without affecting the longevity was found.

After this the next step of research; data collection was initiated. The primary data was collected by individually measuring the illumination level of each artifacts and tabulating them. As per the schedule, site visits were made on different days to ensure proper study of the site.

As preparation for site visits, the required instrument and paper works were made earlier. Lux meter required was managed from C.E.S(Centre for Energy Studies) and excel sheets were made prior to the survey. Luxmeter named HTC LX-101 was used for the survey purpose. Since Namuna Ghar is a personally owned heritage, I had to take permission with the owner of the house, Mr. Rabindra Puri for the visit. After the permission, the survey at Namuna Ghar was conducted on 27 February 2023. Data related to lighting including illuminance level and power consumption was measured on site with the help of lux meter. An open ended conversation with the owner relating to the museum was also done.

In a similar manner, the survey at The National Museum was conducted on 12 July 2023. There were different blocks in the museum where different types of artifacts were exhibited. The "Juddha Jatiya Kalashala" had a variety of artifacts so the further study was carried on this specific block only. The staffs at museum were excited to see the "Lux meter" and were eager for this research work. I was surprised to hear, " Oh so this is the instrument that can measure the illumination level?" since they were from Archaeological background and were appointed for ensuring preservation of the artworks and artifacts. An open ended interview was done with the staffs and electrician personnel of the museum regarding the type of light, its power, working hours and so on. Lux levels on each artifacts on the level where artifacts was placed was measured. The staffs were so cooperative and friendly that they literally opened the locks of display case lighting elements so that the data could be taken. The data were then tabulated in the excel forms for further analysis.

The next survey was conducted on the Military Museum on 15 July 2023. The artifacts displayed were thoroughly checked out. Then, illumination level was measured on each artifacts related to painting and metal artifacts. Due to security issues, in this museum unlike in the National Museum of Nepal, the illumination level of artifacts placed inside the glass display was not measurable. They were sealed and not openable. Due to this reason, an indirect measure of illumination was taken in this museum. For this process, the illumination level of lighting just above the glass and immediately beneath the glass was measured on one of the openable glass. The difference in between the illumination level was found yo be 100 lux. So, assuming this difference to occur in each display case lightings, an additional value of 100 lux was made on measured lux value outside the glass of each display case lighting elements. The data were tabulated for data analysis.

The step was then followed by data analysis process where the quantitative data obtained from all three sites were taken. Average mean of all data recorded was calculated. They were then tallied with the standard data from the literature review and compared to its accuracy. The value addition this research could give to the government, the related organizations and to the heritages were analysed. At the end, the research could clearly show if the illumination levels in museums of Nepal were appropriate or not.

4. Areas of study

Three museums of Nepal; one on a small scale, another on a national scale and the last one being space designed actually for museum namely Namuna Ghar of Bhaktapur, National Museum of Nepal, and the Military Museum of Nepal respectively were surveyed in this research work. The three museums are owned by different levels. The Namuna Ghar being owned by an individual, the National Museum of Nepal owned by the Government of Nepal and the Military Museum owned by the Army of Nepal. The elaborated study is in following sections:

4.1 Namuna Ghar

Namuna Ghar, located in Datattraya, Bhaktapur, is a remarkable heritage site that stands as a testament to Nepal's rich medieval art, architecture, and history. This historical structure has a heritage dating back 150 years, undergoing a significant restoration process that revitalized its fading glory. The dedication to maintaining its authenticity and historical value was rewarded when the house received the esteemed UNESCO Asia-Pacific Awards for Cultural Heritage Conservation in 2004 [12].

Figure 2: Exterior facade of Namuna Ghar

This restoration project successfully achieved a fusion of traditional craftsmanship, artistic expressions, and historical significance with the necessary modern amenities. Namuna Ghar stands as a living example of the country's commitment to preserving its cultural heritage, offering a glimpse into its illustrious past while celebrating its enduring legacy. The house itself acts as an artefact for the people loving traditional heritage and also for the people of Bhaktapur having similar kind of houses. It represents the beauty of maintenance in traditional buildings.

Different artifacts made up of wood, metal, terracotta, paintings etc. were exhibited here. Elements representing Newari architecture was displayed here. The elements were displayed in the niches made in the walls. The entire house had spaces exhibited as living space, workspaces, kitchen dining spaces, study spaces and so on following the functionality of a typical Newari house.

Figure 3: Artifacts displayed at Namuna Ghar

The lighting illumination of each artifact was measured and compared. The following chart gives the idea of lighting in the museum:

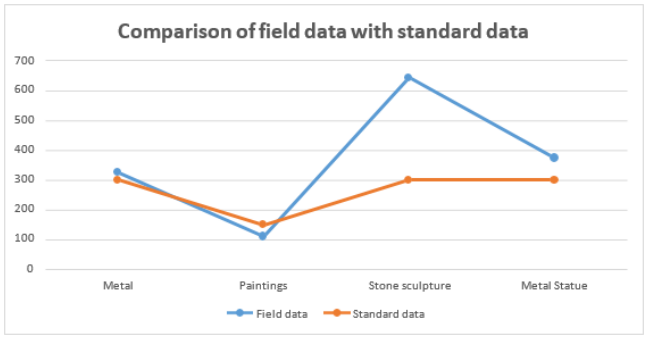

Figure 4: Comparison of field data with standard data at Namuna Ghar

The graph can clearly show that the illumination level required for the preservation of artifacts have not been provided carefully. In case of metal artifacts, stone sculpture, the illumination level exceeds the standard data whereas in case of paintings, the illumination level is not meeting the standard data. In both the cases, the artifacts will only degrade and not glorify the importance it holds. It was also noticed that despite the difference in type of artifact displayed, same type of luminaire was provided for the artifacts ignoring the illumination level it required. It may be because they were unaware of this. Also there is no such guidelines to follow in Nepal even if someone wants to follow. This clearly means that the intensity of lamps needs to be revisited in this museum for the preservation and longevity of the artifacts.

Table 2: Electrical consumption in present state

Monthly Electricity Cost Calculation			
Approved Load		15 Amperes	
Total Unit		134.655 Units	
Unit Range	Units(K Wh)	Rate(Rs./Unit)	Total(Rs.)
0-20	20	4	80
21-30	10	6.5	65
31-50	20	8	160
51-100	50	9.5	475
101-250	34.65	9.5	329.175
Total Units	134.65		1109.175
Minimum charge		100 rupees	
Monthly Electrical cost		1209.175 rupees	
Yearly Electrical cost		14510.1 rupees	

Table 2 shows the electrical consumption of the museum in the present state with the existing bulbs and equipment. The electrical cost of building after replacing the bulbs with only the required level of illumination was done and again the electrical bill was calculated which is shown as:

Table 3: Electrical consumption after bulb replacement

Monthly Electricity Cost Calculation			
Approved Load		15 Amperes	
Total Unit		108.825 Units	
Unit Range	Units(K Wh)	Rate(Rs./Unit)	Total(Rs.)
0-20	20	4	80
21-30	10	6.5	65
31-50	20	8	160
51-100	50	9.5	475
101-250	8.825	9.5	83.8375
Total Units	108.825		865.8375
Minimum charge		100 units	
Monthly Electrical cost		963.8375 rupees	
Yearly Electrical cost		11566.05 rupees	

After calculating the electrical power consumption of the building, it is clear from the data above that it was possible to save up Rs. 3321 per year on the same usage of the lighting need in the museum. Though this amount seems to appear less, in a long term, it will be a huge amount. On calculating the payback period for the replaced bulbs, it was found that the payback period was as short as 0.6 years which is a viable form of replacement. Due to this reason the need for change in the illumination level according to the artifacts displayed was identified.

4.2 National Museum of Nepal

The National Museum of Nepal is situated in Chhauni, Kathmandu, close to the Swayambhu hills. Adjacent to the main historical gallery is the Art Gallery(The Juddha Jatiya Kalashala). The structure is named 'Juddha Jatiya Kalashala' in honor of the then Rana Prime Minister, Juddha Shumsher,

who personally financed its construction in the year 1999-2000 B.S [13]. This building holds significance as the first structure erected specifically for museum purposes.

Figure 5: Exterior facade of Juddha Jatiya Kalashala

Within this gallery, visitors can explore an array of exhibits including stone sculptures, terracotta sculptures, wooden sculptures, textile paintings, and more. The stone sculptures showcased in this gallery represent diverse iconographic features, styles, and the philosophical outlook of the Nepali people across different historical eras. These sculptures serve as a reflection not only of the evolution of Nepali stone art over nearly 1900 years but also provide insights into the exceptional talent of ancient Nepali artists [13].

Overall, the National Museum of Nepal, with its Art Gallery and historical exhibits, serves as a repository of the country's cultural heritage, allowing visitors to connect with the rich history and artistic prowess of Nepal through the various artifacts and pieces on display. The building is two storied and consists of four big exhibition halls; two for metal artifacts, one for stone artifacts, and one for the paintings. The halls are approachable through the corridors surrounding the lobby space where the staircase for upper floor and a statue of Juddha Shumsher is kept as a focal element. The use of adjustable track lights was found to be used maximum. A good aspect of the museum was that all lights used were L.E.D. lights which consume comparatively low energy than the incandescent ones.

Figure 6: Artifacts exhibited at Juddha Jatiya Kalashala

The lighting illumination of each artifact was measured and compared. The following chart gives the idea of lighting in the museum:

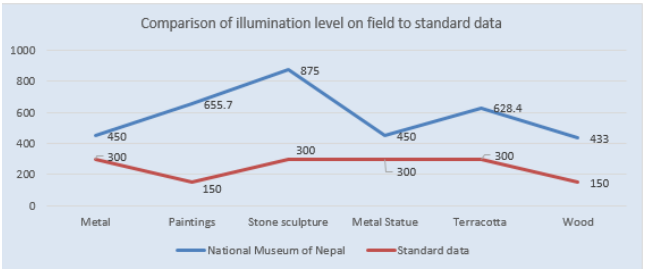

Figure 7: Comparison of field data to standard data

Upon taking the lumen value of each and every artifact of different materials the mean data was taken and was compared with the standard data from the literature. There was a huge difference in what was needed than what was required. The illumination level provided seem to be harsh to the artifacts since they had higher level of illumination than what was actually needed. On a longer run, if the artifacts are exposed to this type of lighting, the artifacts will degrade soon. So, due to this reason there is also a need to revisit the lighting measures in this museum as well.

Again, on calculating the total electricity consumption of the building and replacing the bulbs to meet the required illumination level, a huge consumption of energy and monetary value was seen. As shown in Figure 8, this adjustment could lead to a remarkable reduction in energy consumption, amounting to approximately 4500 units of electricity. This energy conservation effort not only contributes to environmental sustainability but also translates to substantial cost savings. The projected annual savings in terms of monetary value are estimated to be Rs. 47,742. The chart is shown in Figure 8.

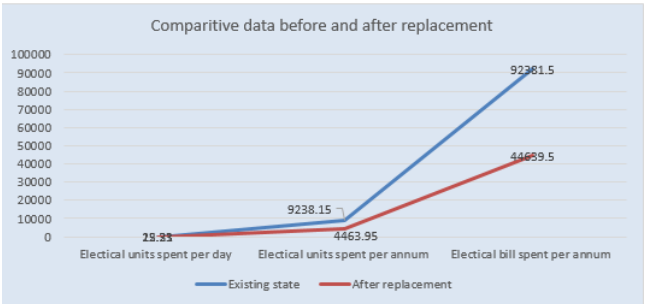

Figure 8: Comparison of difference in energy consumption and electricity bills

This realization underscores the potential benefits of adopting illumination practices that prioritize artifact preservation without compromising on energy efficiency. It's a win-win case for both energy/ monetary perspective and the archaeological perspective. Such measures not only serve the museum's commitment to safeguarding its collection but also have positive implications for its operational expenses and environmental impact.

4.3 The military museum

The military museum is situated opposite the National Museum in Chhauni, and is a must go place for enthusiasts of military history. Its construction took place in December 2000, with its official inauguration following in July 2005. While the museum remains in a state of ongoing development, efforts by the army to amplify its scope and historical artifacts are evident. Inside, the museum boasts a rich array of historical collections, including Nepal's inaugural Rolls-Royce, a gift from Queen Elizabeth II, and a Skyvan transport plane [14].

The museum space is housed on a three storey building out of which the museum is placed only in the ground floor. The upper floors are not accessible to the public and are used for their own purposes. The layout of the exhibition space goes smooth throughout and the circulation is easy. One can enjoy the hide and seek of lights inside the museum. The major exhibits are the paintings of the war and the weapons used in the war.

Figure 9: Exterior facade of Military museum

Despite the presence of exterior openings in the building as shown in Figure 9, they have been effectively sealed off using cardboards and plywood, resulting in a deliberate absence of natural lighting within the museum. This strategic choice directs the lighting conditions entirely towards artificial sources as shown in Figure 10. The illumination levels of each artifact was done with the help of lux meter. In places where the direct measurement of lux levels could not be done, the measurements were taken from the surface just outside the glass. In the place where the glass shelf could be opened, the difference in measure of lux value at the surface of glass and inside the glass was done and it was found to be around 100 lux. So, in each data taken at surface of glass which could not be opened due to security reasons, 100 lux has been added to its lux value. The collected lux data was averaged for metal artefacts and paintings and were compared with the standard data which is shown in Figure 11.

Similar to the findings in the two other surveyed museums, as shown in Figure 11, this museum also demonstrates a disparity in illumination levels. Paintings are subjected to excessive lighting, potentially risking their preservation, while metal artifacts suffer from inadequate lighting conditions that may hinder their visibility and appreciation. Notably, the variance between the surveyed illumination data and the standard benchmarks appears to be narrower in comparison to the other two museums, indicating a relatively more aligned approach in this museum.

Figure 10: Artifacts displayed at Military museum

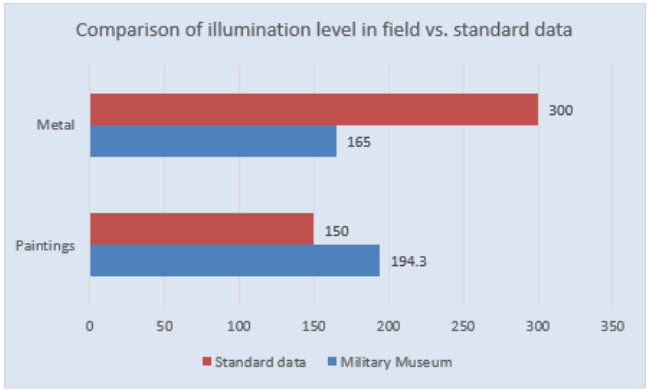

Figure 11: Comparison of illumination level in field vs. standard data

5. Discussions and Analysis

As a final step of research, all data of each museum were plotted at a single graph to conduct comparative studies in between museums. The comparative study of illumination levels in between different museums surveyed is presented below in graph:

As per Figure 12 shown below, we can finally draw some findings of the research. The minimum illumination level should not fall below 50 lux. The illumination level for low sensitive objects, medium sensitive objects and high sensitive objects were found to be 300 lux, 150 lux and 50 lux respectively. None of the three museums surveyed have met the illumination standards as per the literature standards. The artifacts are either subjected to inadequate illuminations or excess illumination levels. In case of inadequate lighting, the visitors will be unable to clearly see the artifacts. In case of excess lighting, the intensity of light for a longer term can degrade the artifact, fade its color and even cause the breakdown. Certain amount of energy can be saved from each

museum without affecting the performance of museum. The future generation to come may or may not see this piece of artifact if the lighting intensity persists as of now.

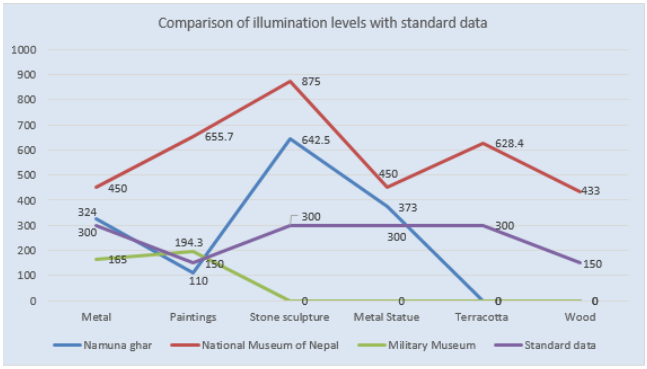

Figure 12: Comparison of illumination data of all museums with the standard data

6. Conclusion

The sole purpose of this research was to calculate the total energy consumption of the museums and identify the places to intervene so that energy could be saved. On conducting the research, huge amount of energy finally leading to electrical bills that could be saved were found. Another objective of the research was to survey if proper amount of illumination is provided to the artifacts or not. The results came negative. The required illumination level was not provided to the artifacts.

This observation raises concerns about the preservation and display of artifacts within these institutions. The consequences of inadequate or excessive lighting are substantial. In instances of insufficient illumination, visitors may struggle to fully appreciate and comprehend the displayed artifacts due to poor visibility. On the other hand, excessive lighting poses even graver risks. Prolonged exposure to overly intense light can lead to the deterioration of artifacts, causing fading of colors, structural breakdown, and long-term damage.

This emphasizes the critical importance of proper illumination in museum settings. The aim should be to strike a delicate balance that allows for optimal viewing while safeguarding the longevity and integrity of the artifacts. To address this issue, museums should consider revisiting their lighting strategies and adopting illumination practices that align with established standards, ensuring both visitor engagement and artifact preservation.

This research indicates the need of proper guidelines in Nepal for each type of building so that the energy is also saved and the work is also done efficiently. A set of guidelines or strategies can also be developed so that corrections could be done in existing ones and guidelines could be followed in the upcoming museums to be made in the future.

Hence, we can conclude saying that lighting energy efficiency in museums can be done by implementing innovative energy-saving strategies to preserve both artistic value of artifacts and also the environment, after all “TO CONSERVE ENERGY IS, TO GENERATE ENERGY.”

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