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Architectural Layout for a Three-Story Dormitory Integrating a Rainwater Harvesting Infrastructure

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Abstract: *Residing within a college dormitory entails convenient strolls to classes, easy access to friends just down the corridor, and an immersion in the vibrant campus social milieu. The paper emphasizes the efficacy of the building's structural design in terms of robustness and durability, as well as how the building's aesthetics can hold a competitive edge on a global scale, all while adhering to the safety standards outlined in the building regulations of the Philippines. The design of the dormitory, complete with a rainwater harvesting system, encompasses various stages. These include the collection of data to establish the project's foundation, the creation of an architectural design to conceptualize the project, structural design and analysis to ascertain the building's strength and load-bearing capacity, electrical design to outline lighting and power plans, plumbing design to organize water distribution and determine suitable pipe sizes, a comprehensive work program detailing construction timelines and schedules, and cost estimates to gauge labor, equipment, and material expenses. The project's design, validated through tools like structural design software, adhered to the Philippines' National Building Code and National Structural Code, meeting all requirements without encountering failure or errors. The building's prerequisites underwent meticulous evaluation and verification. Consequently, it is implied that the project holds practical value and is both feasible and worthwhile.*

Keywords: architectural, dormitory**,** dome, rainwater, harvesting, infrastructure

I. INTRODUCTION

In contemporary times, a considerable number of students are inclined to explore distant locales as a means to challenge their independence, while others actively seek superior educational prospects beyond their immediate surroundings. Consequently, a notable proportion of these students embark on quests for accommodations that offer convenient proximity to their educational institutions and align with their personal preferences. One popular lodging choice that aligns with these criteria is the dormitory.A dormitory, colloquially known as a "dorm," encompasses a substantial building that is subdivided into numerous rooms, intended to house college students. Institutions of higher learning across the globe typically furnish their students with the option of single or multiple occupancy rooms within these dormitories. Notably, the architectural layout and administration of dormitories often cater to specific gender considerations; thus, dormitories are frequently organized to house individuals of a single sex. In certain instances, arrangements are made to segregate sexes either by allocating separate floors or entirely distinct rooms.[1].

The relevance of rainwater harvesting becomes pronounced in the face of water scarcity issues. This practice involves the collection and storage of rainwater to be utilized on-site, as opposed to letting it simply drain away. Rooftops serve as prime collection points, channeling rainwater into reservoirs where percolation often takes place [2].The presence of Surigao State College of Technology – Del Carmen Campus holds a unique position within the locality of Del Carmen, Surigao del Norte, being the sole higher education institution situated in the area. Its affiliation with a highly regarded college institution adds to its prominence. However, this distinction also underscores the challenge of inadequate lodging options for non-local students.

Rainwater harvesting is a straightforward process involving the collection of water from surfaces upon which rain descends, followed by its storage for subsequent usage [5]. The conventional practice encompasses the collection of rainwater from building rooftops, which is then stored within rainwater tanks [6]. This practice is notably prevalent in

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rural areas of Australia. Additionally, water can be amassed in reservoirs through the accumulation of rain on the ground, leading to runoff [7, 8]. PAGASA, the Philippine Atmospheric, Geophysical and Astronomical Services Administration, is entrusted with safeguarding against natural disasters, ensuring the populace's safety, well-being, and economic stability. This institution provides weather forecasts, tropical cyclone alerts, flood bulletins, advisories, as well as hydrological, climatological, and farm weather predictions. Their involvement is essential in amassing data on prevailing weather conditions and the annual rainfall quantities recorded in Del Carmen, Surigao del Norte, over a span of at least a decade. This comprehensive dataset is imperative to conducting a robust study, critical for the successful execution of the project.

Non-local students attending the Surigao State College of Technology – Del Carmen Campus often face the need to commence their day earlier than their peers residing in Del Carmen. This early start is imperative to facilitate their commute from home to the campus, a journey that spans varying distances [9]. Given this predicament, the establishment of a dormitory emerges as an imperative requirement for both the institution and its student body. Constructing a dormitory on campus grounds serves a dual purpose. Primarily, it addresses the immediate need for suitable accommodation for out-of-town students. Secondly, its strategic placement ensures that not only is lodging provided, but also the added convenience of proximity. The proposed dormitory's accessibility to the campus guarantees that students can enjoy not only a place to stay but also enhanced ease in reaching their academic facilities [10, 11].

II. METHODS

Illustrated in Figure 1 is the sequential progression of the study, commencing with the acquisition of pivotal data and culminating in the attainment of the research's objectives. The initiation phase involves an on-site visit aimed at procuring essential data requisite for the formulation of a comprehensive design plan for the proposed three-story building. This data holds significance as it serves as the foundational information upon which the structural dynamics of the building are predicated. Subsequent to this site-oriented data collection, attention shifts to amassing pertinent rainfall statistics. This endeavor is pivotal for the eventual design of the rainwater harvesting tank, which hinges on accurate rainfall data. Following data acquisition, computer applications are engaged to facilitate meticulous computations and generate visual representations derived from the compiled dataset. The ensuing phase encompasses thorough data analysis, constituting an instrumental precursor to the design phase. It is through this analysis that insights crucial for the design's development are extracted. Coupled with these analytical insights, the researchers embark on crafting the rainwater collection system. This system is conceptualized as an innovative alternative water source, strategically designed to alleviate the prevailing water scarcity on the site [12, 13, 14].

In the research process, initial designs are formulated to align with the specific requisites of the school campus, taking into account the students' needs. These designs are tailored to fulfill the established criteria and necessitate adherence to the National Building Code and National Structural Code of the Philippines. This evaluation gauges the feasibility of the preliminary designs concerning both their structural integrity and economic viability, an inherent aspect of civil engineering. Moreover, compliance with Batas Pambansa Blg. 344 is essential to determine the building prerequisites related to provisions for enhanced mobility of individuals with disabilities. Similarly, alignment with the Fire Code of the Philippines is pursued to uphold public safety and stimulate economic growth by averting and suppressing destructive fires, thereby elevating the fire service profession[15].

Concomitant with the structural design process, the rainwater harvesting system is an integral facet of the study. As a primary step, the researchers undertake the collection of rainfall data and pattern analysis. Subsequently, the design of the catchment area ensues, followed by the formulation of a water supply system catering to the building's demands. The culmination of this project yields a comprehensive design blueprint for a three-story dormitory. This blueprint is the result of meticulous analysis aligned with prevailing construction codes, complemented by an ingeniously designed rainwater harvesting system.

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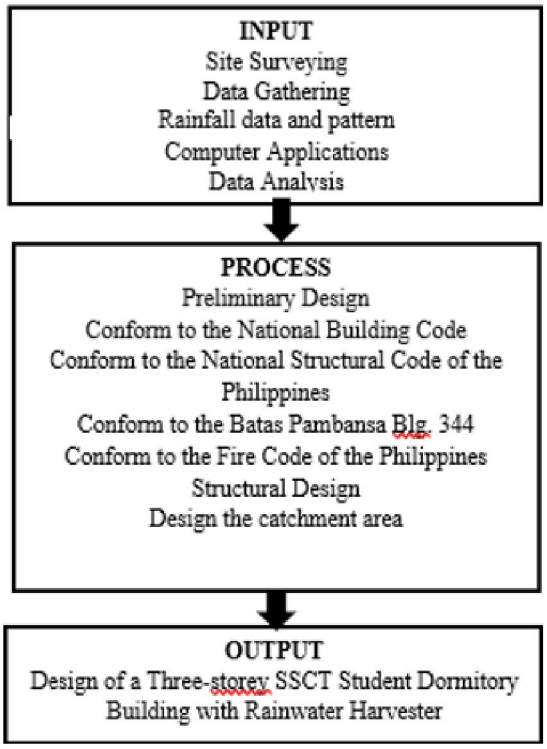

Figure 1. Flowchart oftheStudy

2.1 Project Design

The study comprehensively addresses the methodologies essential for the successful design of a dormitory building integrated with a rainwater harvesting system. The building structure employs a contemporary concrete framing system, in line with prevailing construction practices, while the rainwater harvester tank is strategically positioned underground, adjacent to the building.

The design process for the dormitory building equipped with a rainwater harvesting system involves a multifaceted approach as shown in Figure 2. It commences with the crucial step of data gathering, forming the bedrock for project initiation. Subsequently, the architectural design phase ensues, facilitating the conceptualization of the project's blueprint. In tandem, the structural design and analysis phase takes center stage, ensuring the building's robustness and load-bearing capacity align with the stringent stipulations of the National Building Code and National Structural Code of the Philippines.

Integral to the project, the design of the rainwater storage tank is meticulously undertaken. This phase determines the tank's optimal size to accommodate sufficient rainwater for serving as an alternative water source for the building. The electrical design aspect entails meticulous planning of lighting and power distribution, coupled with precise wattage and voltage determinations. Plumbing design encompasses the layout of water distribution lines and the specification of appropriate pipe dimensions.

To ensure effective project management, a comprehensive program of works is developed, outlining timelines and schedules for the construction process. A precise cost estimate is generated to gauge labor, equipment, and material expenditures. Additionally, plans are meticulously drafted using drafting and graphic software, facilitating the creation of realistic visualizations that capture the building's final form.

The research encompasses a comprehensive exploration of the methodologies required to proficiently devise a dormitory building complemented by a rainwater harvesting system. The architectural framework of the building employs a contemporary concrete framing system, while the subterranean placement of the harvester tank is strategically positioned adjacent to the building.

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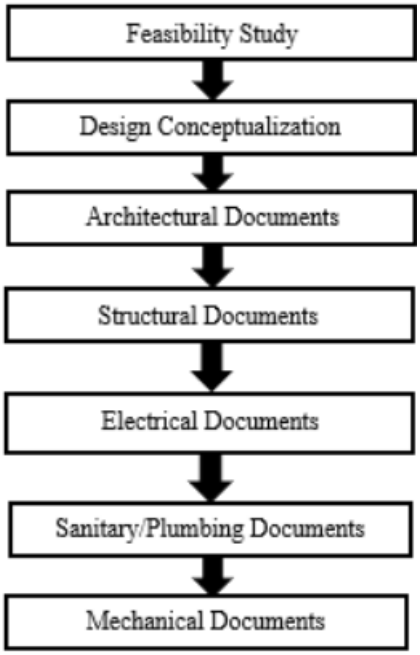

Figure 2. Project Design Chart

2.2 Project Setting

The proposed project's location as shown Figure 3 holds a pivotal role in shaping its design and functionality. Nestled within the vibrant landscape of [Location Name], the setting exudes a unique blend of [mention any distinct features, such as urban vibrancy, natural beauty, or cultural significance]. This strategic positioning not only influences the architectural considerations but also plays a significant role in addressing the specific needs and aspirations of the intended occupants. As we delve into the intricate design process of a dormitory building integrated with a rainwater harvesting system, the context of [Location Name] adds a layer of significance, contributing to a harmonious fusion of purposeful design and environmental consciousness. The project is situated at Surigao State College of Technology – Del Carmen Campus, Del Carmen Surigao del Norte. The existing vacant lot property owned by the institution will serves as the lot area of the soon-to-rise structure. The project coordinates are at 9°52'26.1"North and 125°58'13.5" East situated across the Surigao State College of Technology, Del Carmen campus, Surigao City.

Figure 3. Location of the Project

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2.3 Instruments

Within this study, various computer-aided software tools will be harnessed as instrumental aids, facilitating a streamlined and expedited realization of the research objectives.

Drafting Software serves as a powerful tool for crafting floor plans, building permit drawings, landscaping layouts, and building inspection plans. This software expedites the creation of designs with heightened precision, bypassing the need for traditional stencils and technical drawing instruments. Its capabilities in 2D drafting allow for swift and accurate design conceptualization.

Graphic Software, on the other hand, possesses the prowess to transform three-dimensional images and videos into tangible visual spectacles, enriched with captivating visual effects. This software promises to infuse life and vibrancy into the architectural designs of the study, elevating their impact. This dynamic visualization tool serves as a pivotal asset in presenting the comprehensive design.

Further enhancement comes from Structural Design Software, an engineering application designed to facilitate the analysis, modeling, and design of structures. This software promises accurate and efficient computations, significantly streamlining the complex processes inherent in structural engineering. With widespread adoption in modern construction practices, this software promises an effective approach to structural design.

Microsoft Office emerges as an invaluable suite of tools that align with contemporary work practices. Comprising tools like Microsoft Excel, Microsoft Word, and Microsoft Project, it seamlessly caters to the multifaceted demands of this study. Microsoft Office aids researchers in generating reports, crafting construction estimates, and implementing PERT-CPM techniques for streamlined project management. Notably, Microsoft Project aids in estimating costs and creating a comprehensive breakdown of construction expenses. Additionally, it facilitates scheduling, enabling effective tracking to ascertain if the project adheres to predetermined timelines.

Collectively, these software tools significantly expedite the research process, enabling researchers to execute tasks more efficiently and produce outputs of exceptional quality.

2.4 Ethical Considerations

Navigating the design process of a dormitory necessitates a conscientious approach that extends beyond architectural ingenuity. Ethical considerations play a pivotal role in shaping the blueprint, ensuring that the creation not only meets functional and aesthetic criteria but also adheres to a set of moral imperatives. This entails safeguarding the well-being of the residents, preserving the environment, and respecting the rights of all stakeholders involved. In this brief exploration, we delve into the ethical dimensions that underpin the design of a dormitory, examining how these considerations influence decisions and contribute to the creation of a harmonious and responsible living space.

The researcher is committed to ensuring minimal environmental disruption throughout the course of this study. Respondents' participation is entirely voluntary, with no coercion exerted by the researcher. Furthermore, respondents possess the right to withdraw from the study at any point. To safeguard public safety and property, the design of the structural system adheres to the standards stipulated in the National Structural Code of the Philippines series 2015.

III. RESULTS AND DISCUSSION

The collection and analysis of rainfall data stand as foundational components in the realm of rainwater harvesting. Rainfall data serves as a crucial resource, offering insights into the frequency, intensity, and distribution of precipitation within a specific region. This vital information not only guides the design and sizing of rainwater harvesting systems but also ensures their optimal functionality and efficiency. In this concise exploration, we delve into the significance of rainfall data as a driving force behind the successful implementation of rainwater harvesting practices. Table 1 displays the maximum captured rainfall along with its corresponding five-year average in cubic meters for Surigao Del Norte, as sourced from PAGASA's records.

Employing the catchment approach, the researcher devised the tank design as shown in Figure 4 , determining the minimum essential capacity of the storage tank. The system's configuration encompasses three prevalent designs, including an embedded tank and two tanks positioned atop a water tank tower. The first tank, Tank 1, possesses a total capacity of 14 cubic meters, while Tank 2 and Tank 3, both cylindrical in shape, hold capacities of 16 cubic meters each. Their collective capacity amounts to 46 cubic meters.

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TABLE 1: AVERAGE RAINFALL DATA

	2015	2016	2017	2018	2019
JANUARY	134.1	26	179.8	178.8	88.9
FEBRUARY	46.2	44	78	184.8	45.6
MARCH	17	11.8	118.2	71.6	48
APRIL	63.2	21.2	94.6	36.2	32.8
MAY	17.3	20.4	68.1	36	59.2
JUNE	145	61.5	42.7	143.9	27.8
JULY	10	78.5	50.8	37.2	58.3
AUGUST	43.8	56.2	46.6	21.2	17.4
SEPTEMBER	85.1	77.2	42.4	50.4	7.2
OCTOBER	44.8	58.2	82	84.8	43.7
NOVEMBER	81.5	174.2	55	81.1	45.9
DECEMBER	112.4	89	104.6	94.2	104.8
AVERAGE	66.7	59.85	80.23	85.02	48.3

In consideration of the rainwater harvesting framework, the researchers made an assumption centered around the organizational structure of the three-story building. This structure consists of 56 bedrooms, alongside 3 offices, with provisions for 400 individuals to access comfort rooms. Based on a consumption rate of 20 liters per day, this projection yields a daily requirement of 8000 liters.

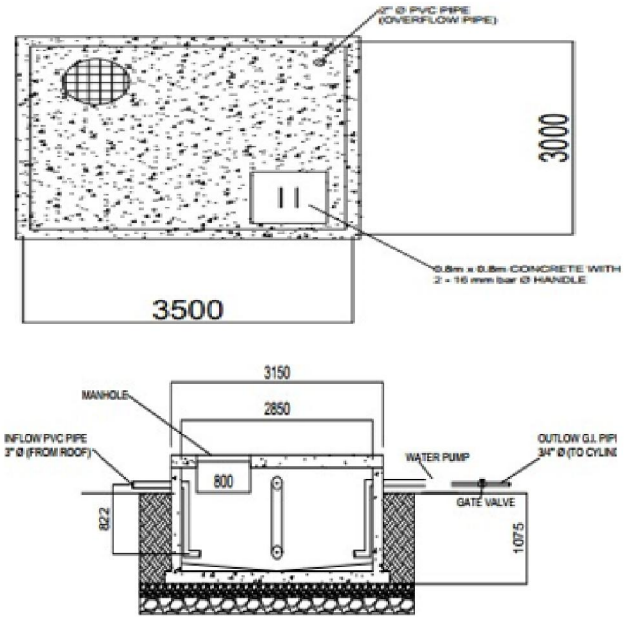

Figure 4: Tank Design

The researcher conducted an analysis of a structure, considering both its aesthetic and structural prerequisites in alignment with the Campus Director's directives. Specifically, the Campus Director of SSCT del Carmen articulated a preference for a contemporary design, reflective of current architectural trends. The researchers successfully realized the Campus Director's vision by conceptualizing a three-story dormitory building that seamlessly integrates modern elements. This design caters to a substantial number of occupants while incorporating a gender-segregated arrangement – two separate buildings in close proximity, each furnished with its own cafeteria and convenience store. This innovative approach effectively addresses the stipulated demands.

Spanning across a lot area of 1473.5 square meters, the researcher adeptly met the spatial requisites outlined by the Campus Director. To ensure sustainable water management, a rainwater harvesting tank has been integrated, poised to provide water during supply shortages within the building.

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Leveraging the capabilities of graphic software, Figure 5 showcases the perspective view of the SSCT student dormitory, meticulously designed by the researcher to align with the Campus Director's explicit requirements.

Figure 5: Perspective View of the Project

The ground floor plan as shown in Figure 6, of the dormitory serves as the foundational blueprint that lays the groundwork for a functional and harmonious living space. This initial design iteration intricately maps out the arrangement of spaces and facilities, offering a glimpse into the meticulous planning behind the structure. The ground floor's layout not only encompasses the physical dimensions of rooms and common areas but also reflects the vision of creating an inclusive and conducive environment for the dormitory's occupants. This introduction provides an insightful overview of the spatial arrangement and design principles that underlie the dormitory's ground floor plan, offering a glimpse into the thoughtful considerations that shape its form and function.

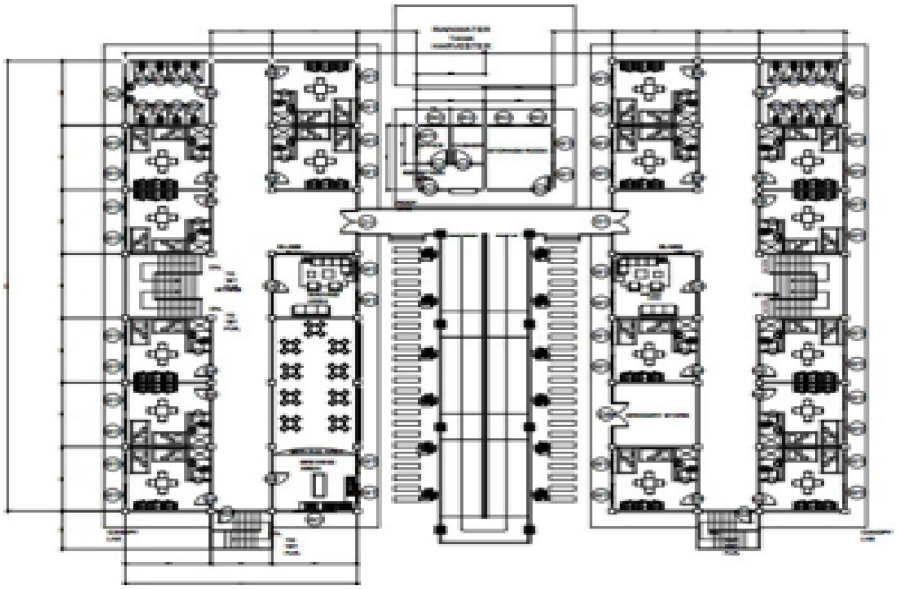

Figure 6: Ground Floor Plan

The second and third floors of the dormitory as shown in Figure 7, represent the successive levels in a multi-story narrative that unfolds within the architecture. These floors transcend mere physical elevation, serving as integral components of an interconnected living space designed to meet the diverse needs of its occupants. As we ascend through the floors, we venture into realms of learning, rest, and social interaction. Each floor plan, meticulously crafted,

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is a manifestation of thoughtful design principles that harmonize individual privacy with communal engagement. In this exploration, we delve into the intricacies of the second and third floors, unraveling the deliberate choices that have sculpted these spaces into cohesive and nurturing environments for the dormitory's residents.

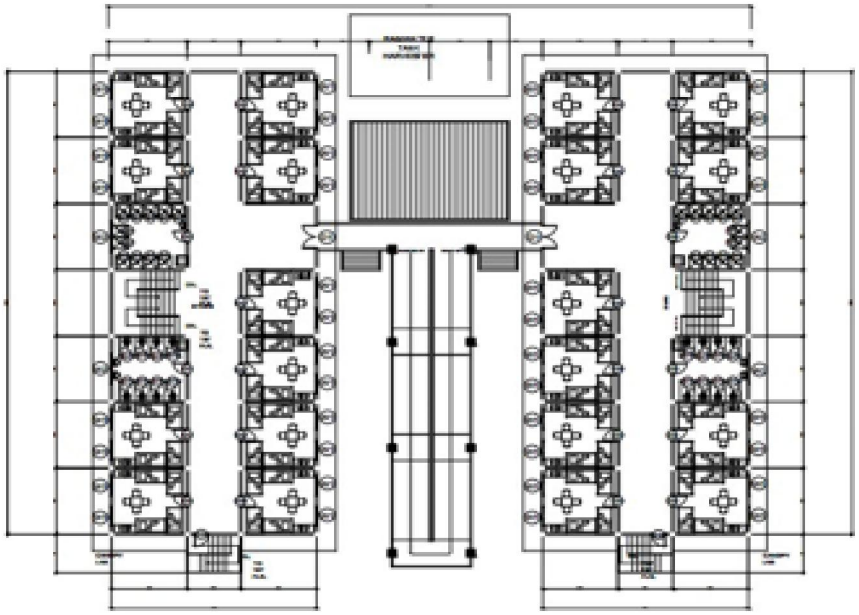

Figure 7: Second to Third Floor Plan

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- In culmination, the design of the three-story dormitory accompanied by a rainwater harvesting system presents a harmonious integration of architectural innovation and environmental consciousness. Through an intricate process of meticulous planning, comprehensive data analysis, and collaboration with modern software tools, a cohesive blueprint was achieved that not only meets the structural and aesthetic requirements but also aligns with ethical and sustainability considerations.
- The incorporation of rainwater harvesting technology responds to the pressing need for alternative water sources, particularly in regions prone to supply shortages. The adept utilization of rainfall data and analysis ensured the sizing and positioning of the rainwater harvester tank in congruence with the specific demands of the location. This strategic integration not only offers a sustainable solution but also exemplifies a commitment to resource conservation and responsible infrastructure.
- Furthermore, the dormitory's design thoughtfully addresses the diverse needs of its occupants. The spatial arrangement, from the ground floor to the upper levels, blends private spaces with communal areas, fostering an environment conducive to both solitude and interaction. The adherence to building codes and standards, as confirmed through rigorous structural testing, attests to the structural integrity and safety of the design.
- Ultimately, the collective efforts of architectural ingenuity, engineering precision, and environmental consciousness converge to yield a holistic design that not only fulfills its functional objectives but also embraces a sustainable future. This project stands as a testament to the potential of harmonizing human habitation with responsible resource management, laying the groundwork for a more sustainable and resilient built environment.

4.2 Recommendations

- It is recommended to establish a system for continuous monitoring of rainfall patterns to ensure optimization of the system

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- It is recommended to establish a structured maintenance for rainwater harvesting components including the storage tank.
- Consider incorporating renewable energy sources, such as solar panels to power dormitory systems

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