MSU-IIT Center for Resiliency
Office of the Vice Chancellor for Research and Enterprise

Determination of Rainwater Volume Collected from Roof Buildings for Appropriate Design of Rainwater Storage Capacity and its Utilization in MSU-IIT

Project Progress Report

AUGUST 2023

PROJECT PROPOSAL
CY 2022-2023

Project Title: Determination of Rainwater Volume Collected from Roof Buildings for Appropriate Design of Rainwater Storage Capacity and its Utilization in MSU-IIT

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1. **Problem:** Rainwater runoff from the buildings contribute to flooding.
2. **Solution:** Rainwater Harvesting Project mitigates the flooding problem inside MSU-IIT Campus and helps conserve water and water expenses by using harvested rainwater for purposes of sanitation, plant maintenance and fire control.
3. **Objectives of the Project**
   - 3.1 Come up with a **rainwater harvesting technology design** that has the maximum storage capacity equivalent to a monthly rainfall during the rainy season to be installed in each building in MSU-IIT and is easy to clean and maintain.
   - 3.2 Materialize a suitable **roof drainage design** integrated with a filtering system that effectively catches all accumulated rainwater and debris from building rooftops and acts as an inlet to each building's designated rainwater storage tank.
   - 3.3 Design an overhead **pump system** in each rainwater storage tank as a mechanism to lift water for distribution for sanitation purposes, fire control, and greenery maintenance.
   - 3.4 Design a hydrant with faucet in each rainwater storage tank for fire control and greenery maintenance as part of the **utilization and disposal system design**.
   - 3.5 Create a **flood mitigation model** after rainwater has been harvested .
   - 3.6 Develop a **tripartite systematic plan** that involves **management**, **implementation**, and **investment** of the rainwater harvesting project in MSU-IIT.

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I. Introduction and Objectives

Water scarcity and flooding are two critical challenges that many urban areas face today. As climate patterns continue to shift, the occurrence of heavy rainfall events leading to localized flooding has become a pressing concern. Educational institutions, as integral components of urban environments, are not exempt from these challenges. One such institution grappling with these issues is the Mindanao State University - Iligan Institute of Technology (MSU-IIT). The excessive runoff from buildings during heavy rains has not only contributed to flooding within the campus but has also strained water resources and expenses. In response to this multifaceted problem, the **Rainwater Harvesting Project** emerges as a sustainable and innovative solution.

Rainwater harvesting is the collection and storage of rainwater for reuse on-site. It is a sustainable way to manage water resources and can help to reduce flooding, conserve water, and save money.

This project aims to determine the rainwater volume collected from roof buildings for appropriate design of rainwater storage capacity and its utilization in MSU-IIT. The project is motivated by the problem of flooding in the MSU-IIT campus, which is caused by rainwater runoff from the buildings. The project also seeks to conserve water and water expenses by using harvested rainwater for purposes of sanitation, plant maintenance, and fire control.

This project will help to mitigate the flooding problem in MSU-IIT, conserve water, and save money. The project will also provide a valuable educational opportunity for students to learn about rainwater harvesting and its benefits.

The findings of this research project will contribute to the body of knowledge on rainwater harvesting in schools. The project will also provide a replicable model for other schools that are looking to implement rainwater harvesting systems.

A. MSU-IIT Demographics and Geography

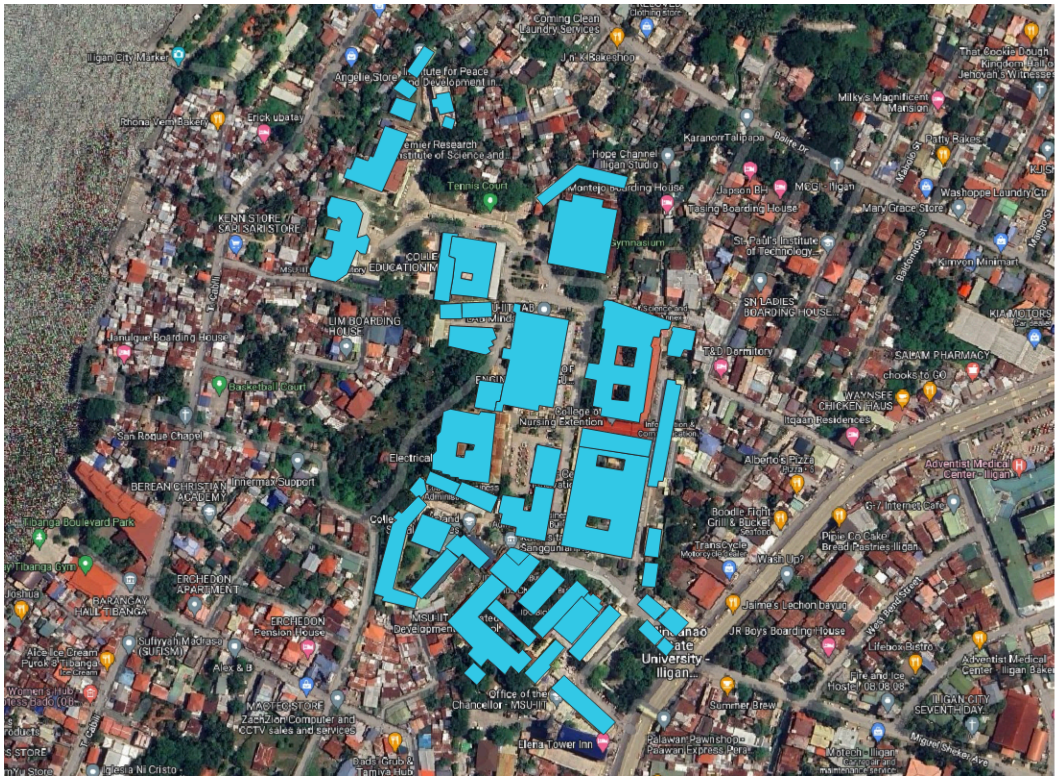


Figure 1. Geotagged GIS Map of MSU-IIT.

To enhance clarity and precision in small-scale and other illustrative representations, each building within MSU-IIT was assigned a unique letter designation. This labeling system was implemented to facilitate clear identification and differentiation of buildings in various visual materials, aiding in the effective communication of architectural and spatial information throughout the project.

A - IDS, HAll	M - College of Compute Studies
B - BET-Lab Building	N - Admin Building
C - College of Engineering & Technology	O - Main Library
D - Gymnasium	P - College of Education
E - College of Nursing	Q - College of Arts and Social Sciences (New)
F - College of Science and Mathematics	R - Supply
G - Graduate Dormitory	S - iDeya
H - CASS Old Small Rooms	T - Registrar & Admissions Building
I - College of Education Annex 1 - Twin Court	U - MiCel

J - PRISM K - College of Arts and Social Sciences (Old) L - College of Economic and Business Administration	V - IPDM W - KTTO X - Clinic Y- Balay Alumni

Table 1.A List of buildings and their corresponding guiding code.

B. Project Framework

The Rainwater Harvesting Project at MSU-IIT follows a comprehensive framework that encompasses various stages, from initial assessment to final implementation. This structured approach ensures the successful integration of rainwater harvesting systems across the campus, addressing flooding issues and promoting sustainable water management. The project framework can be outlined as follows:

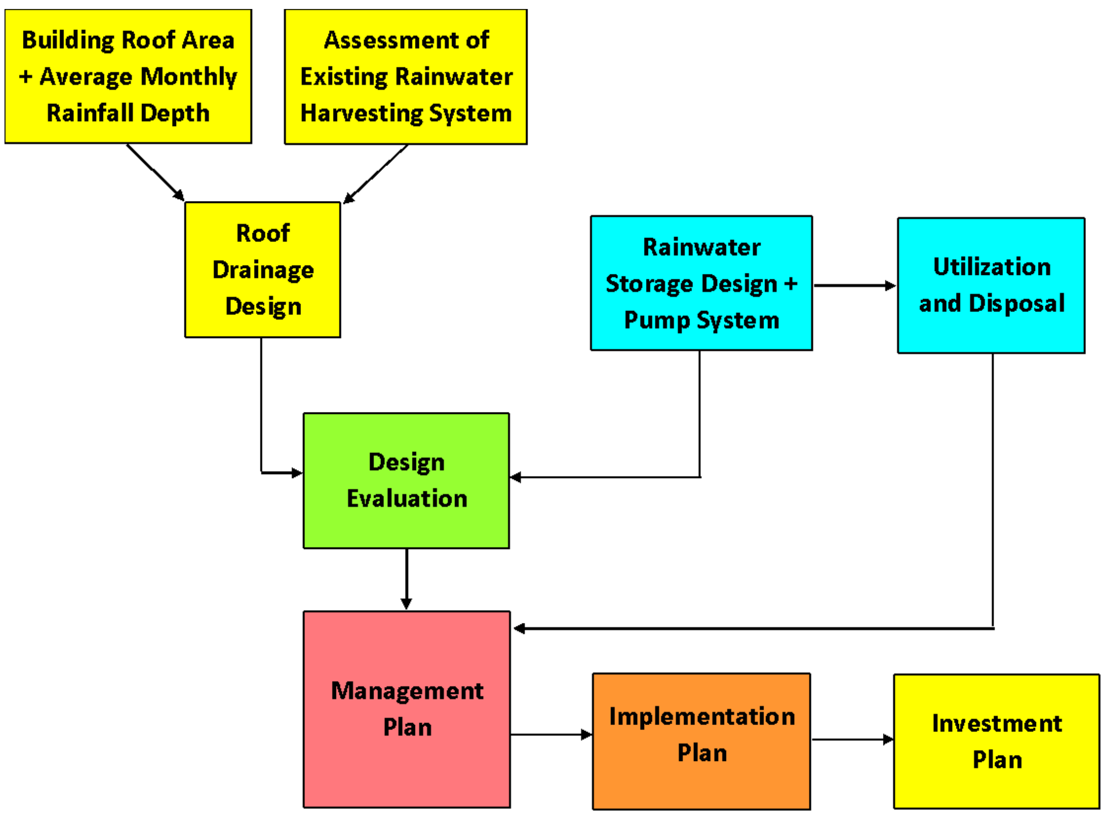


Figure 1.B Project Framework

1. Initial Assessment:

- Determine the total building roof area across MSU-IIT campus.
- Gather historical rainfall data to establish the average monthly rainfall depth during the rainy season.
- Assess the effectiveness and efficiency of any existing rainwater harvesting systems within the campus.
- Identify the specific areas and buildings where rainwater runoff contributes significantly to flooding.

2. Roof Drainage Design:

- Utilize the building roof area and average monthly rainfall depth to design an effective and efficient roof drainage system.
- Ensure that the drainage design is capable of channeling rainwater and debris from rooftops to the rainwater storage tanks.
- Implement appropriate filtration mechanisms to prevent debris from entering the rainwater storage tanks.
- Evaluate the feasibility and practicality of the proposed drainage design through simulations or modeling.

3. Rainwater Storage Design and Pump System:

- Determine the optimal rainwater storage capacity based on the monthly rainfall depth and anticipated water demand.
- Design rainwater storage tanks that are suitable for the campus's architectural and spatial constraints.
- Integrate an overhead pump system within each rainwater storage tank to facilitate water distribution.
- Ensure that the pump system is reliable, energy-efficient, and capable of delivering water to designated areas for various purposes.

4. Utilization and Disposal Plan:

- Develop a plan for utilizing harvested rainwater for sanitation, fire control, and greenery maintenance.
- Design hydrants and faucets within the rainwater storage tanks to enable easy access for fire control and maintenance activities.
- Ensure that the rainwater quality meets the required standards for the intended uses.
- Establish protocols for regular maintenance, cleaning, and monitoring of rainwater storage tanks and distribution systems.

5. Management Plan:

- Create a comprehensive management plan outlining roles, responsibilities, and communication strategies among project stakeholders.

- Define protocols for system maintenance, monitoring, and addressing any operational issues.
- Detail contingency plans for addressing unexpected challenges or emergencies related to rainwater harvesting and utilization.

6. Implementation Plan:

- Develop a timeline for the phased implementation of rainwater harvesting systems across different buildings.
- Identify key milestones, resource requirements, and potential obstacles during the implementation process.
- Allocate tasks to relevant teams or individuals responsible for installing roof drainage systems, rainwater storage tanks, and pump systems.

7. Investment Plan:

- Estimate the overall budget required for the project, including material costs, labor expenses, and any associated infrastructure upgrades.
- Explore potential funding sources, such as institutional funds, grants, or partnerships.
- Outline the financial sustainability of the project, considering long-term cost savings from reduced water expenses and flood mitigation.

8. Evaluation and Continuous Improvement:

- Regularly monitor the performance of the rainwater harvesting systems and assess their impact on flooding reduction and water conservation.
- Gather feedback from stakeholders and make necessary adjustments to improve system efficiency and effectiveness.

II. Project Methods & Design

A. Data Gathering, Assessment & Findings

1. Initial Assessment:

A. Determine the total building roof area across MSU-IIT campus.

The total building roof area across the MSU-IIT campus was determined through a process involving digital mapping. Using Google Earth, the roofs of all buildings within the campus were digitized and subsequently exported to a Geographic Information System (GIS) platform. This facilitated the computation of the area for each individual building roof, forming a basis for subsequent stages of the project.

Bldg. No.	Building Name	Roof Area (m^2)

1	SET - Old Building Complex	4629.031
2	College of Science and Mathematics (CSM)	3330.337
3	Gymnasium	2975.622
4	College of Engineering (COE)	2730.505
5	College of Arts and Social Sciences (CASS) - OLD	2599.222
6	IDS Complex	2211.681
7	SET - New Building Complex	2023.846
8	Graduate School Dormitory	1650.326
9	College of Economics, Business, and Accountancy (CEBA)	1322.573
10	College of Education (CED)	1321.054
11	PRISM Building	1181.017
12	College of Computer Studies (CCS)	833.931
13	Department of Health Science	830.816
14	Supply and Property Management Division (SPMD)	802.877
15	PITAFFI	783.698
16	CBAA Building 1	783.17
17	IDS - Laboratory Building	725.512
18	DOST Building	695.157
19	PE Classrooms	681.531
20	IDS - Science Building	638.228
21	College of Arts and Social Sciences (CASS) - NEW	626.312
22	Main Library Building	611.14
23	Administration Building	607.298
24	Physical Plant Division	588.118
25	Bahay Alumni Building	558.61
26	Institute Canteen	547.907
27	IDS - Faculty Building	525.517
28	Office of the Chancellor	517.125
29	CEBA Annex	482.885
30	Automotive Laboratory	463.431
31	Ceramics Laboratory	430.309
32	Hostel	293.288
33	MICeL Building	276.638
34	IPAD Building	269.249

35	STP	241.629
36	Institute Clinic	241.234
37	KTTO Building	198.721
38	EMPC Building	190.122
39	KASAMA Office	172.636
40	Executive Multi-Purpose	120.381
41	Trash Storage	119.226
42	Security Office	63.2

Table II.A.1.A Building numbers of each building in MSU-IIT and their corresponding Roof Area (m^2)

This table presents the roof area data for each building. Notably, the Bldg. No. 1 - SET - Old Building Complex exhibited the largest roof area, measuring 4629.031 square meters.

B. Gather historical rainfall data to establish the average monthly rainfall depth during the rainy season.

The study utilized historical rainfall data obtained through PHIVOLCS - REDAS's Satellite Rainfall Monitor (SRM) software, which has the capability to retrieve and assess rainfall data from 2000 (JAXA) to the present. Researchers attended a training organized by DOST-PHIVOLCS, led by Dr. Maria Leonila P. Bautista, to learn about hazard monitoring tools including ETAM and SRM. The training covered software installation, configuration, and practical utilization, with lectures from DOST-PAGASA. For the study, SRM was used to retrieve historical rainfall data from GSMAP JAXA servers, or NESDIS NOAA if not available. Rainfall data from January 1, 2018, to December 31, 2022, was collected and converted to daily rainfall depth using MS Excel.

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
2022	72.9	110.1	331.4	435.7	241	210.9	378.4	292.1	288.1	337.9	141.6	282.2
2021	288.6	226.4	148.2	117	371.6	312.7	245.9	327.1	314.2	313	235	248.8
2020	33.4	7.2	137.3	86.5	294.8	376.3	380.8	391.5	241.6	291.9	120.7	399.4
2019	237.3	0.5	126.2	72.8	206.5	378.2	347.1	102.4	134.3	354	213.2	135.5
2018	231.6	105.4	38.6	163.6	443.7	298.6	155.7	303.3	375.5	255.2	208.9	70.8
AVERAGE	**172.76**	**89.92**	**156.34**	**175.12**	**311.52**	**315.34**	**301.58**	**283.28**	**270.74**	**310.4**	**183.88**	**227.34**

C. **Identify the specific areas and buildings where rainwater runoff contributes significantly to flooding.**

The identification of specific areas and buildings where rainwater runoff significantly contributes to flooding was accomplished through a series of site assessments and visits. Multiple visits were carried out across the entirety of MSU-IIT's buildings to thoroughly inspect and evaluate the condition and functionality of key components such as Roof, Gutter, Downspout, and Catch. These meticulous checks allowed for a comprehensive understanding of areas prone to flooding due to inadequate rainwater management.

Pipe and Drainage. During the inspection process, a thorough evaluation of water flow and pipe systems was conducted to track the trajectory of water movement and entry points. The site visit revealed instances where *water backflow occurred especially around buildings G and I*, leading to localized flooding in certain areas. This insight underscores the need for improved rainwater management measures to address these backflow issues and mitigate the occurrence of floods within the affected areas.

Assessment evaluation of water flow and pipe systems in MSU-IIT

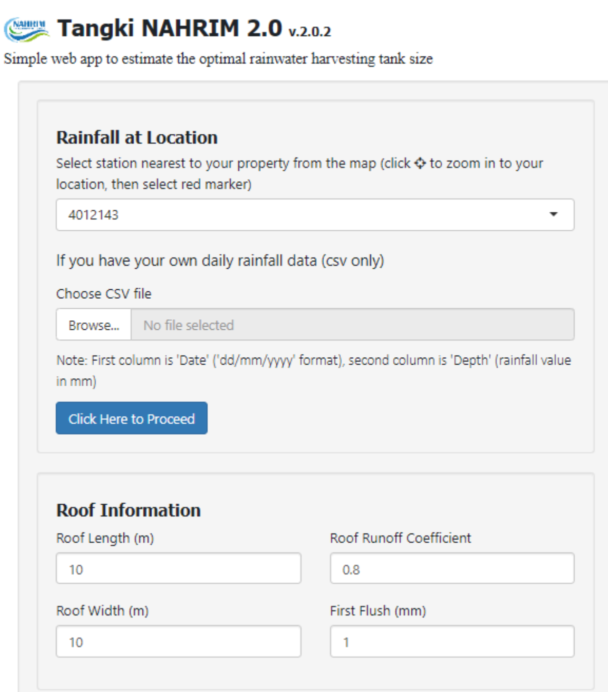
Roof, gutter and downspouts. Roof, gutter, and downspout systems are crucial components in implementing a rainwater harvesting technology as they collectively ensure the efficient collection, channeling, and conveyance of rainwater from rooftops to storage facilities, optimizing the capture and utilization of this valuable resource.
An assessment was carried out to evaluate the operational status and overall condition of the roof, gutter, and downspout systems for each building. This assessment encompassed all buildings, with individual evaluations conducted and summarized for

each structure. Notably, buildings such as KTTO and MICeL, which were equipped with existing rainwater harvesting systems. Furthermore, structures marked as "FAILED" were not considered, unless they underwent necessary repairs prior to the implementation phase.

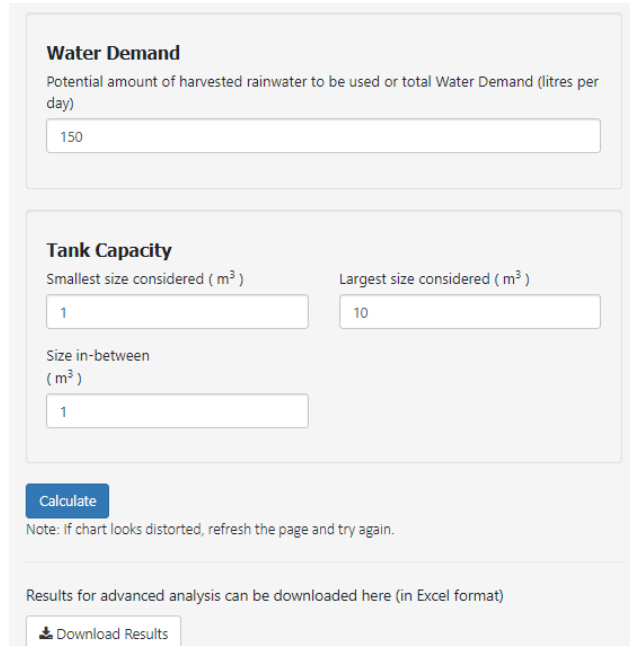
		Condition			
Bldg. No.	**Building Name**	**Roof**	**Gutter**	**Downs pout**	**Assessment**
1	SET - Old Building Complex	Poor	Failed	Poor	Failed
2	College of Science and Mathematics (CSM)	Good	Fair	Fair	PASSED
3	Gymnasium	Good	Good	Good	PASSED
4	College of Engineering (COE)	Good	Fair	Good	PASSED
5	College of Arts and Social Sciences (CASS) - OLD	Good	Good	Fair	PASSED
6	IDS Complex	Poor	Failed	Failed	Failed
7	SET - New Building Complex	Good	Good	Good	PASSED
8	Graduate School Dormitory	Excellent	Good	Good	PASSED
9	College of Economics, Business, and Accountancy (CEBA)	Good	Good	Good	PASSED
10	College of Education (CED)	Good	Good	Fair	PASSED
11	PRISM Building	Excellent	Excellent	Excellent	PASSED
12	College of Computer Studies (CCS)	Good	Good	Good	PASSED
13	Department of Health Science	Good	Good	Good	PASSED
14	Supply and Property Management Division (SPMD)	Good	Good	Good	PASSED
15	PITAFFI	Good	Poor	Poor	Failed
16	CBAA Building 1	Poor	Poor	Poor	Failed
17	IDS - Laboratory Building	Poor	Failed	Failed	Failed
18	DOST Building	Failed	Failed	Failed	Failed
19	PE Classrooms	Good	Good	Good	PASSED
20	IDS - Science Building	Poor	Failed	Failed	Failed
21	College of Arts and Social Sciences (CASS) - NEW	Excellent	Excellent	Excellent	PASSED
22	Main Library Building	Good	Good	Fair	PASSED
23	Administration Building	Good	Good	Good	PASSED
24	Physical Plant Division	Failed	Failed	Failed	Failed

25	Bahay Alumni Building	Failed	Failed	Failed	Failed
26	Institute Canteen	Good	Good	Good	PASSED
27	IDS - Faculty Building	Failed	Failed	Failed	Failed
28	Office of the Chancellor	Excellent	Good	Good	PASSED
29	CEBA Annex	Good	Good	Good	PASSED
30	Automotive Laboratory	Poor	Failed	Failed	Failed
31	Ceramics Laboratory	Good	Good	Good	PASSED
32	Hostel	Good	Good	Good	PASSED
33	MICeL Building	Good	Good	Good	PASSED
34	IPAD Building	Good	Fair	Good	PASSED
35	STP	Failed	Failed	Failed	Failed
36	Institute Clinic	Good	Good	Good	PASSED
37	KTTO Building	Good	Good	Good	PASSED
38	EMPC Building	Good	Good	Fair	PASSED
39	KASAMA Office	Good	Fair	Fair	PASSED
40	Executive Multi-Purpose	Good	Good	Fair	PASSED
41	Trash Storage	Failed	Failed	Failed	Failed
42	Security Office	Good	Good	Good	PASSED

D. Optimal Tank Sizes for Buildings



To determine the optimal rainwater harvesting system tank size for buildings, the researchers utilized the



(https://waterresources-nahrim.shinyapps.io/Tangki_NAHRIM/) Tangki NAHRIM 2.0 tool for estimation. In this process, the researchers accessed the Tangki NAHRIM 2.0 website and utilized its user interface. They uploaded a CSV file containing daily rainfall data and inputted key parameters including rooftop catchment area dimensions, runoff coefficient, water demand, and first flush.

The simulation involved specifying a range of tank sizes to identify the most suitable option. Tangki NAHRIM then generated a graphical representation of the simulation results, which could be downloaded. If the initial range didn't yield the optimal tank size, researchers could adjust the range and re-run the simulation.

The set range for tank sizes extended from 1 cubic meter to 20 cubic meters. The software simulated the data and visually displayed the outcomes. Subsequently, the researchers selected a tank size that achieved at least a 60% water saving efficiency, based on a study by Al-Saffar et. al., 2016. This approach allowed for informed decision-making, ensuring that the chosen tank size aligned with water conservation goals while maximizing storage efficiency.

Bldg. No.	Building Name	Optimal Tank Size (cu.m.)

2	College of Science and Mathematics (CSM)	20
3	Gymnasium	20
4	College of Engineering (COE)	20
5	College of Arts and Social Sciences (CASS) - OLD	16
7	SET - New Building Complex	20
8	Graduate School Dormitory	20
9	College of Economics, Business, and Accountancy (CEBA)	20
10	College of Education (CED)	20
11	PRISM Building	14
12	College of Computer Studies (CCS)	15
14	Supply and Property Management Division (SPMD)	12
21	College of Arts and Social Sciences (CASS) - NEW	8
23	Administration Building	8
28	Office of the Chancellor	6
32	Hostel	4
34	IPAD Building	4
36	Institute Clinic	3
38	EMPC Building	3

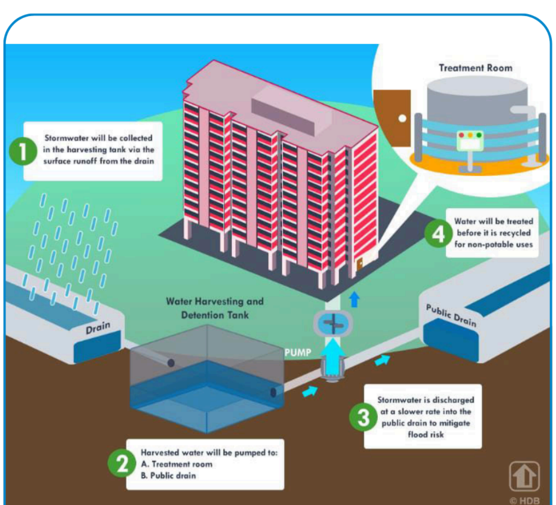
The project employed the Pugh Chart Analysis methodology, as outlined in the study conducted by Ferdjani et al., to make informed decisions regarding the choice of materials. The research by Ferdjani et al. in 2019 identified galvanized steel as the optimal material for the rainwater harvesting system (RHS). Additionally, the study recommended a cylindrical shape due to its ability to evenly distribute stress in all directions. This characteristic is particularly crucial when dealing with water pressure that impacts the container from various angles. The specific dimensions of the cistern were established after collating essential data and conducting calculations to determine the efficiency of the RHS relative to the gathered information. This rigorous approach ensured that the material selection and cistern design aligned with performance and durability requirements.

	Weight Factor	**Concrete**	**Galvanized Steel**	**Fiberglass**	**Polyethylene**

Evaluation Criteria		Rating	Weight	Rating	Weight	Rating	Weight	Rating	Weight
Strength	4	2	8	3	12	2	8	1	4
Resistance to Heat	4	3	12	2	8	3	12	1	4
Cost	5	2	10	2	10	-5	-25	4	20
Ease of Maintenance	3	-1	-3	2	6	2	6	0	0
Corrosion	5	0	0	0	0	3	15	2	10
Facility to Assemble	4	-3	-12	2	8	2	8	3	12
Algae Growth	3	2	6	1	3	-3	-9	-2	-6
Longevity	3	2	6	2	6	3	9	-1	-3
Recyclable	3	-1	-3	2	6	3	9	0	0
	Total		24		**59**		33		41

B. Related Studies & Design

The following images provide glimpses of rainwater harvesting systems from various corners of the world, showcasing diverse approaches and implementations that harness this sustainable water management technique. These captivating visuals portray a range of ingenious designs, from rooftop catchment systems on residential homes to intricately designed community-level rainwater collection structures.



Source: Singapore - The Housing & Development Board (HDB)

In Singapore, rainwater harvesting systems are strategically engineered to optimize the collection of rainwater by harnessing the surface runoff from the expansive ground areas adjacent to multiple residential blocks, as detailed by the Housing

Development Board (HDB). Moreover, this initiative plays a pivotal role in flood control measures, mitigating the impact of heavy rainfall events.

Source: China's Rainwater Harvesting Systems. (rainwaterharvestingsystem.net)

In China, rainwater harvesting methods feature underground modular tanks. These systems efficiently capture rainwater from multiple surfaces, including building rooftops and impermeable pavements. Incorporating a comprehensive filtration process, (includes for large particles,) initial rainwater flush filters and automated rainwater filters for continuous refinement. This reservoir stores collected rainwater.

Source: Australia - Wall aligned tank

In Australia, rainwater harvesting systems often involve tanks strategically positioned parallel to walls, directly capturing rainwater from gutter pipes. This design optimizes the collection process, ensuring efficient transfer from the roof to the tank for storage and subsequent use. However, it's important to note that these systems may lack a comprehensive treatment and filtration process.

Source: Maynilad Rainwater Harvesting System

In the Philippines, a similar practice is employed, utilizing pre-fabricated circular tanks that can be placed anywhere within the area. This approach, known as the Maynilad Rainwater Harvesting System, simplifies rainwater collection. These tanks are typically equipped with a basic faucet for easy utilization and disposal purposes.

These innovative rainwater harvesting solutions from around the world serve as valuable sources of inspiration for the development of an efficient rainwater harvesting system tailored to the needs of MSU-IIT. The diverse approaches observed, whether in Singapore's advanced stormwater management or China's modular underground tanks, and even Australia's direct gutter-to-tank setup, offer insights that can be adapted and integrated into our research and planning for an effective rainwater harvesting system within the context of MSU-IIT's unique requirements and environmental conditions. These global examples underscore the significance of sustainable water management and provide a foundation for our corporate endeavors or research initiatives aimed at enhancing water resilience and resource optimization at MSU-IIT

Numerous studies have recognized the importance of rainwater harvesting as an effective approach to tackle flooding and water scarcity in various settings, including educational institutions. Schools and universities around the world have implemented rainwater harvesting systems to harness the potential of rainwater for both environmental and economic benefits.

1. Sustainable Water Management in Educational Institutions:

Rainwater harvesting in educational institutions has gained attention as a sustainable water management strategy. For instance, the rainwater harvesting systems that have been implemented across the University of Arizona campus offer advantages not only to the water conservation efforts specifically within the campus grounds but also to the broader initiative of conserving water throughout the state of Arizona. The amount of water that is saved each year by these two buildings combined is over 425,000-gallons (Corneliussen, A. 2018). This practice not only conserves water but also aligns with the institution's commitment to environmental stewardship.

2. Mitigating Flooding Through Rainwater Harvesting:

Several studies point out that rainwater harvesting presents itself as a potent strategy for diminishing runoff volume at its origin, thereby serving as an efficient measure to alleviate the risks of urban flooding (Zhang et. al, 2014). Properly designed rainwater harvesting systems can significantly reduce stormwater runoff and alleviate the burden on existing drainage infrastructure. By capturing and storing rainwater from rooftops, the Rainwater Harvesting Project at MSU-IIT aims to prevent flooding within the campus, enhancing the safety and functionality of the entire institution.

3. Economic Viability and Environmental Benefits:

A study shows that incorporating rainwater usage can mitigate water scarcity issues and aid in curbing drainage problems. Moreover, the adoption expenses of this system were minimized by employing budget-friendly alternative techniques and readily available equipment (Muhirirwe et. al, 2021). Not only do these systems offer substantial cost savings by reducing water bills, but they also contribute to environmental conservation by promoting the sustainable use of water resources. MSU-IIT's Rainwater Harvesting Project seeks to emulate these benefits by providing a long-term solution to the campus's water-related challenges.

In line with these studies and global best practices, the Rainwater Harvesting Project at MSU-IIT intends to revolutionize water management within the campus. By designing an efficient rainwater harvesting technology with a comprehensive drainage and storage system, the project aims to maximize rainwater utilization for sanitation, fire control, and plant maintenance. Additionally, the development of a flood mitigation model and a well-structured management, implementation, and investment plan underscores the project's holistic approach to addressing the challenges posed by rainwater runoff and flooding.

Through this endeavor, MSU-IIT demonstrates its commitment to sustainable development, environmental stewardship, and resilience in the face of changing climate patterns. By embracing rainwater harvesting, the institution paves the way for a greener, more water-efficient future while setting a precedent for other educational institutions to follow.

C. Rainwater Harvesting Technology System

Illustration 2.C Rainwater Harvesting Technology System flow.

The Rainwater Harvesting Technology System implemented in this project builds upon the conventional rainwater harvesting process. Rainwater flows from rooftops into gutters, subsequently accumulating in downspouts before entering a storage tank. However, this project introduces innovative enhancements to the traditional approach.

One notable innovation is the integration of a modular filter technology within the downspout system. This advanced filtration system ensures the effective removal of debris and particles, addressing a common issue of clogs and malfunctions. Moreover, the system incorporates sensor technology that signals the opening or closing of gate valves in response to heavy rainfall. This automated mechanism optimizes the efficiency of the rainwater harvesting process, extending the lifespan of storage tanks.

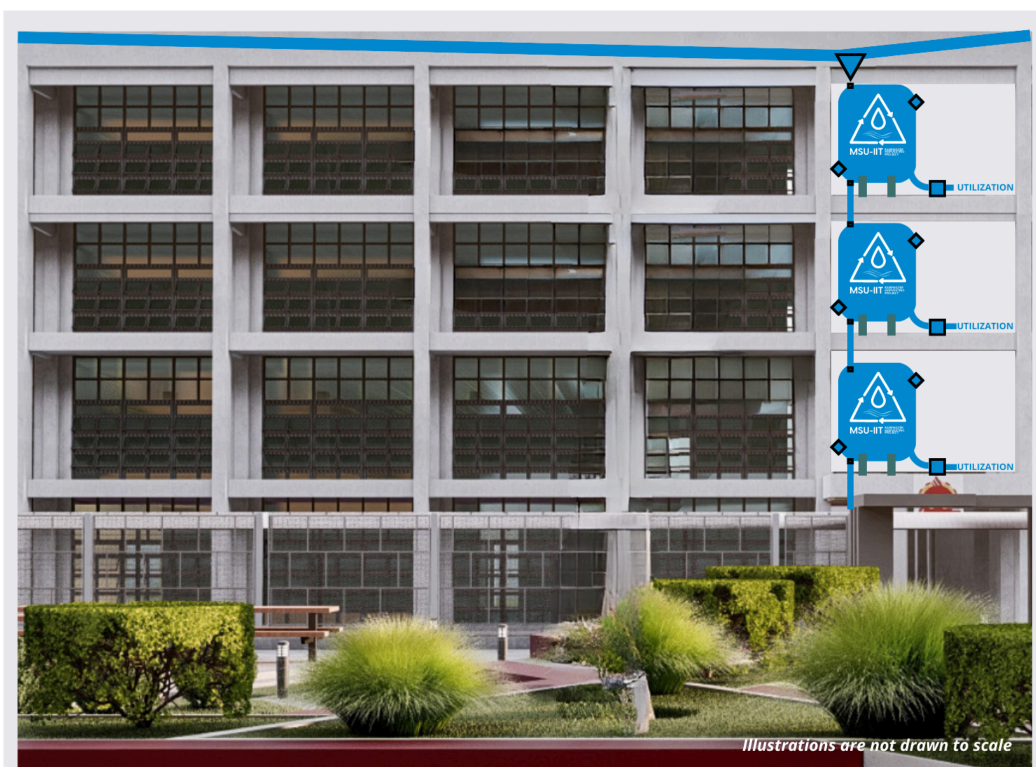
Additionally, the project adopts a "treat only when used" approach. Given the frequent occurrence of heavy rains in Iligan City, the system treats rainwater solely when it is intended for use. This strategy ensures economic viability by avoiding the treatment of water that might be ultimately disposed of without use. This approach aligns with the project's objective of promoting efficient water management in the face of the region's rainfall patterns. By combining these innovative elements, the Rainwater Harvesting Technology System not only captures rainwater effectively but also maximizes its usability and sustainability.

This project establishes two classifications for the implementation of rainwater harvesting systems, differentiating between Building Type A and Building Type B. Building Type A encompasses smaller buildings with one or two-floor levels, while Building Type B pertains to high-rise structures with three or more floors. Each building type will be subject to distinct systems that leverage the same underlying technology but adopt varying approaches tailored to their respective characteristics.

RWH System A for Building Type A entails a singular rainwater storage tank that efficiently captures and manages rainwater as what have shown in the

Illustration 2.C Rainwater Harvesting Technology System flow. Rainwater collected from the roof is directed to this central tank. Utilizing advanced sensors, the system continuously monitors the tank's water level. Once the tank reaches full capacity, the sensors trigger an automatic valve mechanism, releasing excess water into the stormwater drainage system. This might use pumps to bring water to the comfort rooms or utilization. This smart utilization of sensors ensures optimal tank usage, prevents overflow, and contributes to effective rainwater conservation within the building's infrastructure.

RWH System B for Building Type B - Tank per floor. A "Tank per Floor" rainwater harvesting system will be employed. This system capitalizes on gravity to facilitate water storage and distribution. Rainwater from the roof will flow downwards into the nearest tank. Once the tank's sensor detects that it has reached full capacity, a valve will automatically open, allowing water to transfer to the next nearest tank. This sequential process continues until all tanks are filled. Any surplus water beyond the tanks' capacity will be discharged into the stormwater drainage system.

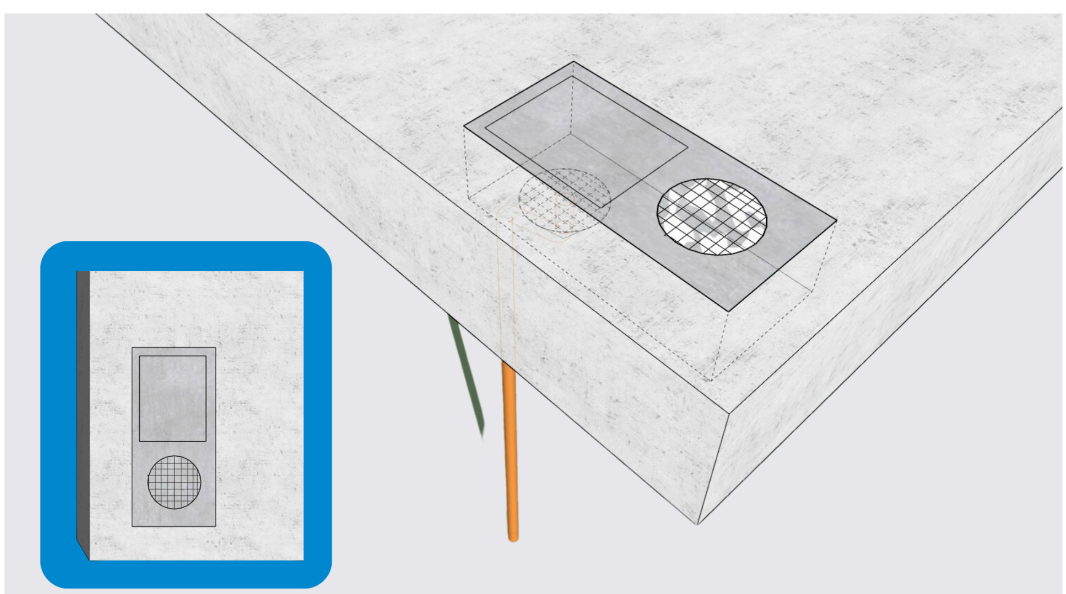


Strategic tank placement is a key consideration for this system. Tanks will be positioned near comfort rooms to enable efficient flushing and other potential uses. Moreover, the structural capacity of the designated areas will be taken into account to ensure the safety and stability of the building.

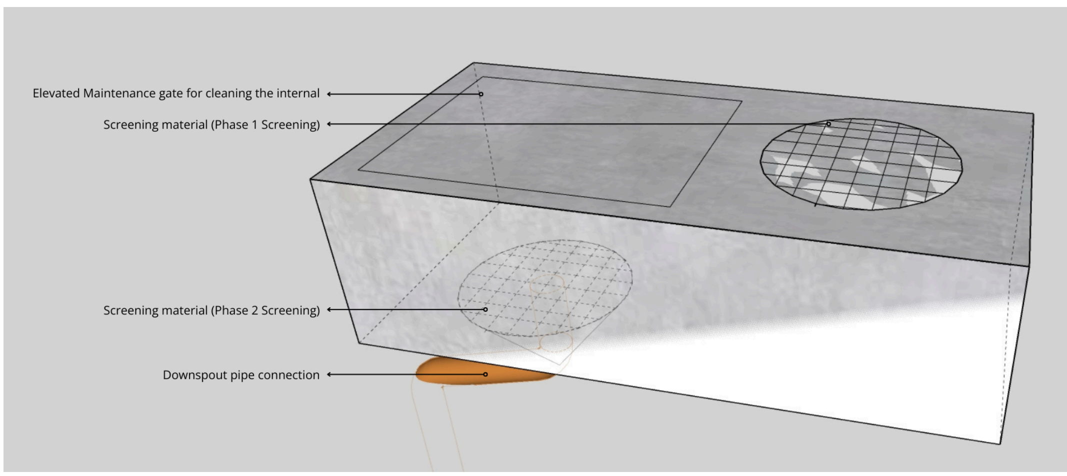
This approach optimizes rainwater utilization within high-rise structures, making the most of vertical space and minimizing the need for additional energy inputs.

D. Roof Drainage System

This rainwater harvesting system capitalizes on the existing roof drainage infrastructure while integrating an innovative modular filter technology. This technology is designed to enhance and optimize the drainage process by effectively intercepting debris and particles, thereby preventing clogs—a common challenge. The proposed modular filter technology is designed to address this issue by seamlessly fitting into the drainage system. This integration aims to improve efficiency, mitigate clogging concerns, and ultimately elevate the effectiveness of rainwater collection and management.



The modular filter device is ingeniously installed and placed within the concrete floor, with its upper portion visibly exposed. Positioned as the initial entry point to the downspout, this device incorporates a dual-stage screening mechanism. The first stage, situated at the top, and the second stage, located internally, work in tandem to comprehensively filter out debris and particles. This meticulous filtration process guarantees the cleanliness of pipes and downspouts, ensuring unobstructed water flow while facilitating hassle-free maintenance procedures.



E. **Pump System**
F. **Utilization and Disposal System Design**
G. **The Monitoring System**
H. **The Control System**
I. **Developing the Monitoring and Control System**
J. **Evaluation of the Monitoring and Control System**

III. **Flood Mitigation Model and Simulations**
   A. **Data from SRM**
   B. **Projected harvested Rainwater volume**
   C. **Flood Map before RWH**
   D. **Flood Map after RWH**

IV. **Tripartite Systematic Plan**
   A. **Management**
      1. **Maintenance and Routines**
   B. **Implementation**
      1. **Plan for implementation**

a) **Specify that the project design assumes 100% functional pipes, roof, and gutters, so it is included in the implementation plan to repair before implementation.**

2. **Integration to the Stormwater Drainage Master Plan**

C. **Investment**

1. **Show savings in terms of water bill, water use**
2. **Include the projected sustainability impact**
3.

V. **Problems/Difficulties Encountered and Proposed/Suggested Solution**

References

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Zhang, Xingqi; Hu, Maochuan (2014). Effectiveness of Rainwater Harvesting in Runoff Volume Reduction in a Planned Industrial Park, China. Water Resources Management, 28(3), 671–682. doi:10.1007/s11269-013-0507-9

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