International Journal of Engineering and Techniques - Volume 12 Issue 1, January-February - 2026

RESEARCH ARTICLE OPEN ACCESS

GIS-Based Multi-Criteria Analysis for Rainwater Harvesting Suitability Mapping in Kamrup Metropolitan District, Assam

Nilakshi Devi[1], Triptimoni Borah[2]

1(M.Tech Student, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati
Email: nilakshi-pg-c-24-30@aec.ac.in)
2 (Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati
Email: btriptimoni@gmail.com)

Abstract: Assam experiences recurrent monsoon flood yet Kamrup Metropolitan District in Assam faces water scarcity due to rapid surface runoff, infiltration and inadequate rainwater storage and recharge practices. Increasing urbanization and building of impervious surfaces have further reduced the effective utilization of rainfall. The present study delineates rainwater harvesting suitability zones using a Geographic Information System (GIS) based multi-criteria decision analysis. The analysis was carried out considering rainfall, slope, drainage density, land use/land cover, soil type and elevation as major controlling parameters. All the six thematic layers were prepared, reclassified and assigned relative weights based on their hydrological influence. A weighted overlay analysis was carried out to integrate the thematic layers and generate the rainwater harvesting suitability map. The map categorizes the study area into high, moderate and low suitability zones. The areas with gentler slopes, permeable soils, lower drainage density and suitable land use conditions show higher potential for rainwater harvesting. The results show a clear spatial pattern with moderate rainwater harvesting suitability covering most of the central urban plain and higher suitability concentrated towards the eastern and southern parts of the Kamrup Metropolitan District.

Keywords - Kamrup Metropolitan, Rainwater Harvesting, GIS, Multi Criteria Decision Analysis, Weighted Overlay Analysis

I. INTRODUCTION

Kamrup Metropolitan district is a monsoon dominated region which often experiences flood during the rainy season but faces water scarcity due to rapid runoff and limited groundwater recharge. Expansion of impervious surface and absence rainwater storage practices have further reduced the effective utilisation of rainfall. Rainwater harvesting provides a practical solution for conservation of rainfall, reducing surface runoff and supplementing local water resources. Rainwater harvesting is widely recognised as one of the effective methods for conserving rainfall, reducing runoff and enhancing groundwater recharge. It depends on several factors such as rainfall, slope, drainage density, soil, land use/land cover and elevation which influence runoff generation and infiltration processes (Preeti et al., 2022)

II. STUDY AREA

The study is carried out in Kamrup Metropolitan district located in the central part of the Brahmaputra valley in state of Assam. It lies on the southern Bank of Brahmaputra River and includes Guwahati as the administrative headquarter and extends approximately between 25°43′-26°51′N latitudes and 90°36′-92°12′ E longitudes, covering area of about 990 km² as calculated from district boundary shapefile. The district is characterized by low lying alluvial plains along the river and gently undulating terrain towards the southern region. It experiences humid subtropical monsoon climate with high seasonal rainfall however rapid organisation have resulted in increased surface runoff and reduced infiltration these characteristics highlight the need for identifying suitable rainwater harvesting zones. The study area has been shown in Fig. 1.

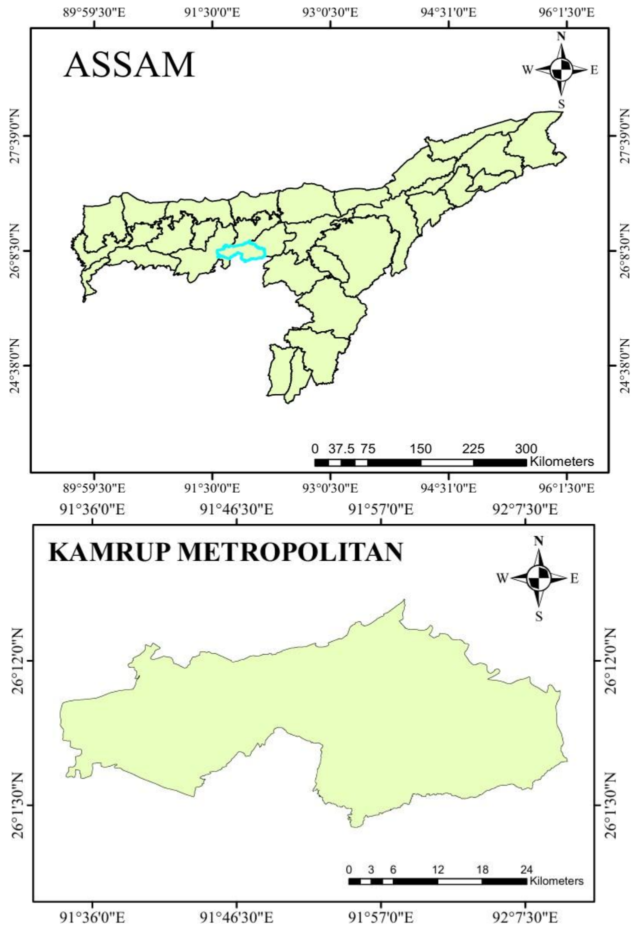

Fig 1. Study Area (Kamrup Metropolitan)

III. METHODOLOGY

The methodology adopted for the study involved a GIS based multi criteria analysis to delineate the rainwater harvesting suitability zones in Kamrup Metropolitan district. The district boundary was obtained from an official dataset and used to define the special extent of the analysis and all thematic layers were clipped to the boundary. The spatial datasets required for the study were collected from multiple sources such as the Digital Elevation Model (DEM) was obtained from SRTM data with a spatial resolution of 30 meter and land use land cover was derived from Landsat 8-9 satellite imagery, soil data were collected from Digital Soil Map of the World (DSMW) and rainfall data were obtained from Climate Research Unit (CRU). The elevation data were pre-processed to remove artificial depressions in order to ensure continuous surface flow and improve the reliability of drainage and slope related parameters before performing the terrain analysis. The thematic layers representing rainfall, slope, drainage density, soil type, land use/ land cover and elevation were prepared and classified into suitable classes based on their influence on rainwater harvesting. Relative weights were assigned to each thematic layer according to their hydrological significance and the layers were integrated to generate the rainwater harvesting suitability map using GIS based multi-criteria evaluation. The final map is classified as high, medium and low suitability areas for rainwater harvesting.

IV. RESULTS AND DISCUSSIONS

To understand the contribution of individual parameters, each thematic layer is analysed separately before integrating the final suitability map.

a) Drainage Density Map

The drainage density map derived from DEM in Fig 2. shows spatial variation reflecting differences in surface runoff behaviour across the study area. The areas categorised by low drainage density indicate wider spacing between drainage channels, suggesting slower runoff movement and greater opportunity for rainwater to remain on the surface for infiltration. Therefore, these zones are more favourable for rainwater harvesting. The regions exhibiting high drainage density represent closely spaced drainage networks, which facilitate rapid runoff and limit water retention therefore making the area comparatively less suitable for rainwater harvesting. The pattern observed in the map indicates that drainage density plays a significant role in controlling the rainwater harvesting potential by influencing runoff concentration and infiltration capacity (Waghaye et al.,2023).

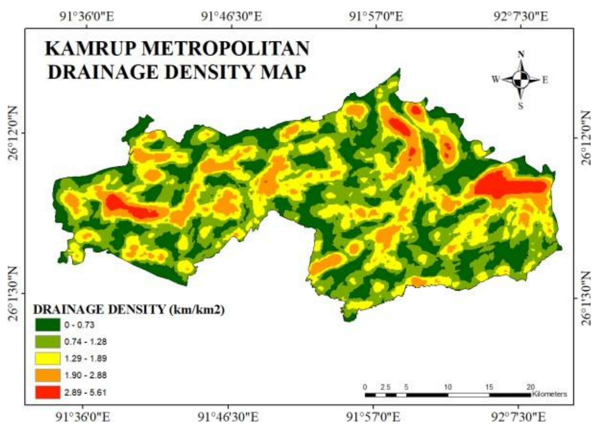

Fig. 1 Drainage Density Map

b) Slope Map

The slope map in Fig 3 shows how land surface varies across the study area and helps in understanding the movement of rainwater after the rainfall events. Slope is an important terrain factor because it controls the speed of surface runoff and the amount of time rainwater remains on the ground, which directly affect the suitability of rainwater harvesting. The area has been classified into five slope categories the very gentle slope class represent almost flat terrain, these areas allow rainwater to accumulate and move slowly, making them highly suitable for rainwater harvesting. The gentle slope category also provides favourable condition as the runoff is limited and can be easily managed. The moderate slope class indicates slightly inclined terrain where runoff therefore such areas are moderately suitable and may require simple run off control measures. In steep and very steep areas rainwater flows rapidly downward reducing surface water retention and limiting the effectiveness of rainwater harvesting (Waghaye et al.,2023)

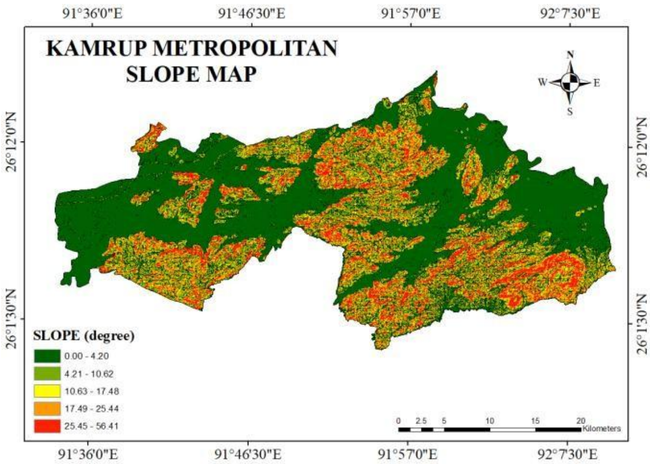

Fig. 2 Slope Map

c) Rainfall Map

The annual rainfall map in Fig 4 was generated using the Inverse Distance Weighting (IDW) interpolation method. It shows the spatial variation in mean annual rainfall which is a very important parameter to determine the rainwater harvesting potential. Rainfall is the most important input for rainwater harvesting as it directly determines how much water can be collected and stored. The study area has been divided into five rainfall categories ranging from 1,506 to 2,156 mm. Zones with moderate to high rainfall combined with favourable surface conditions are more suitable for rainwater harvesting interventions. The spatial pattern observed in the rainfall map highlights the critical role of the rainfall in controlling the overall rainwater harvesting potential when integrated with other thematic layers (Preeti et al., 2022)

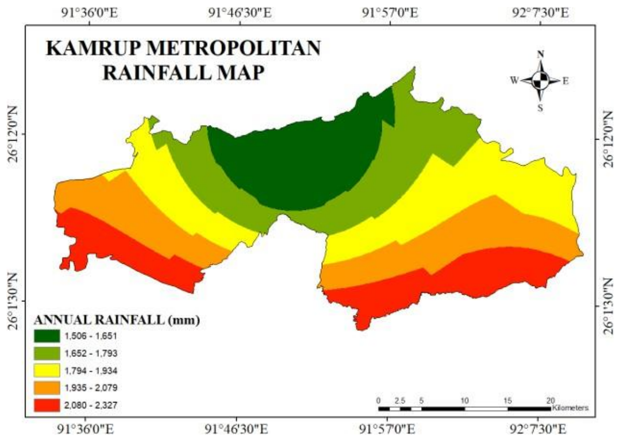

Fig. 4 Rainfall Map

d) Soil Map

The soil map in Fig 5 shows the distribution of three major soil types namely Sandy clay loam, loam and clay which influences the rainwater harvesting potential through its surface behaviour and water holding capacity. Loam soil which covers a substantial portion of the study area are generally favourable for rainwater harvesting as they allow moderate infiltration while retaining sufficient moisture on the surface making them suitable for rainwater collection and storage structures. Sandy clay loam soils also exhibit good rainwater harvesting potential due to balance texture, which support surface retention without rapid loss of water. In contrast the clay dominated areas restrict surface infiltration which can reduce the effectiveness of rainwater harvesting system if not properly managed. The distribution of soil types across the district therefore plays an important role in controlling surface water retention and suitability for rainwater harvesting when combined with other factors such as slope and drainage conditions (Preeti et al., 2022).

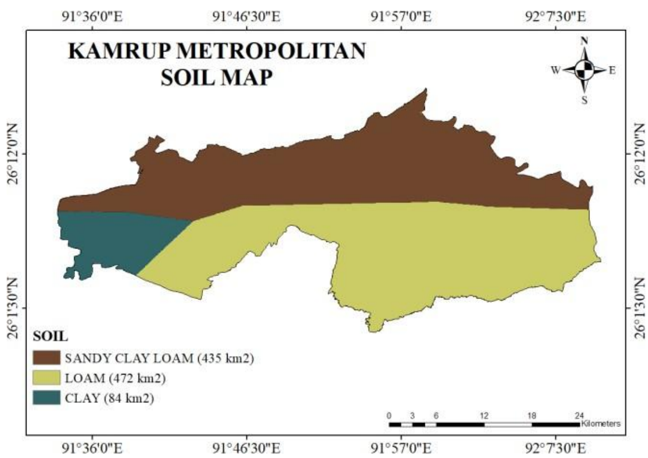

Fig. 5 Soil Map

e) Land Use/Land Cover Map

The land use land cover in Fig 6 plays important role in controlling rainwater harvesting suitability by influencing surface runoff behaviour and the capacity of the land surface to retain rainfall. In Kamrup Metropolitan district vegetation forms the largest land cover class it is the most favourable land cover for rainwater harvesting as vegetative surface reduces velocity and allow rainwater to remain on the surface for effective collection and storage. Agricultural land which covers 6.50% also contributes positively to rainwater harvesting potential due to relatively permeable surface condition and limited surface sealing. The built-up area which covers 40.34 % of the study area shows comparatively lower suitability for surface-based rainwater harvesting because impervious surfaces promote rapid runoff. However, these areas offer considerable potential for rooftop rainwater harvesting system. The water bodies represent existing surface storage and therefore do not directly contribute to rainwater harvesting suitability while sandbars exhibit the least suitability due to unstable surface condition and low water retention capacity. Overall, the LULC distribution indicates that vegetation and agricultural land exert the strongest positive influence on rainwater harvesting suitability while build up areas required site specific harvesting approaches (Preeti et al., 2022).

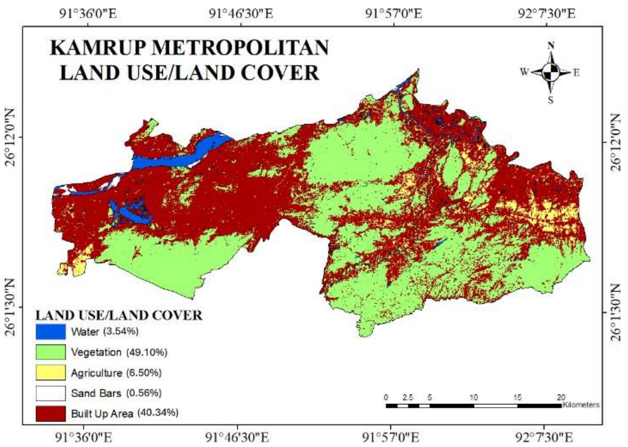

Fig. 6 Land Use/Land Cover Map

The final rainwater harvesting suitability map was obtained by integrating all reclassified thematic layers through a weighted overlay approach using expert judgement within a multi-criteria decision framework. The weighting concept was adopted from previous rainwater harvesting studies (Fetene et al., 2025; Abdulrahman et al., 2024, Preeti et al., 2022). However, the relative importance of each parameter was adjusted to suit the specific terrain, rainfall pattern and land surface condition of Kamrup Metropolitan district. The rainfall was assigned the highest weight (35%) due to its direct control on the volume of harvestable rainwater followed by slope (25%) which strongly influences surface runoff behaviour, soil texture was given a weight of 18% as it affects surface water retention while drainage density is given 12% which represent runoff concentration pattern and land use land cover was assigned 10%, it was assigned a lower weight as it modifies surface conditions for rainwater harvesting but does not directly control rainfall availability or large scale runoff process. The weighted overlay integration of these parameters produces a composite suitability index which was classified into high, moderate and low rainwater harvesting suitability zone representing the combined influence of all controlling factors across the study area.

f) Rainwater Harvesting Suitability Map

The final rainwater harvesting suitability map of Kamrup Metropolitan district in Fig 7 presents the integrated outcome of all controlling parameters and classifies the study area into high, medium and low suitability zones the result indicates that moderate suitability covers the largest portion of the district for approximately 519.84 km^2 and this zone represent areas where rainfall availability is adequate and surface condition moderately supports rainwater collection and retention. High suitability zones cover about 443.25 km^2 and are predominantly observed in the eastern, southern and western parts of the district these areas exhibit a favourable combination of higher rainfall, gentle slope, suitable soil texture, lower drainage density and supportive land use/land cover conditions which collectively enhances water harvesting potential. In contrast low suitability zone are limited in extent and are mainly associated with areas having less favourable conditions such as higher runoff concentration and restricted surface water retention.

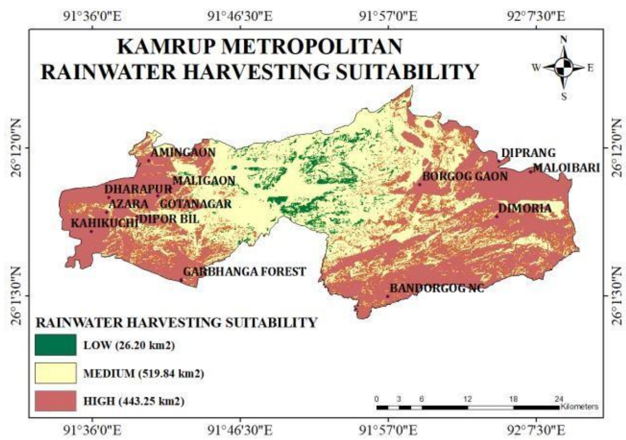

Fig. 7 Rainwater Harvesting Suitability Map

The overall distribution of suitability classes highlights the combined influence of rainfall, terrain characteristics, drainage behaviour, soil properties and land use patterns on rainwater harvesting potential. Similar integrated outcome using GIS based weighted overlay approach have been widely documented in rainwater harvesting suitability assessments. Overall, the suitability map provides a clear framework for identifying priority areas for rainwater harvesting planning and sustainable water management in Kamrup Metropolitan district.

V. CONCLUSION

The study shows the applicability of GIS based multi-criteria decision analysis to delineate rainwater harvesting suitability zone in Kamrup Metropolitan district, Assam. By integrating rainfall, slope, drainage density, soil type and land use/ land cover the analysis captured the combined influence of climatic, topographic and surface characteristics on rainwater harvesting potential. The weighted overlay method has synthesized these parameters into a comprehensive suitability framework. The results show that most part of the study area falls under moderate to high suitability categories areas with gentle slope, favourable soil conditions, lower drainage density and supportive land use pattern of a better potential for rainwater harvesting. High suitability zones indicate location where rainwater harvesting structures can be effectively implemented to reduce surface runoff and improve water availability. Areas classified as low suitability are mainly affected by higher runoff and poor surface retention, and therefore may require alternative or site-specific water management measures.

Overall, the suitability map provides a practical and reliable basis for planning rainwater harvesting interventions in the study area. the findings can support sustainable water resource management and assist planners and decision makers in addressing water scarcity and runoff related problems.

VI. FUTURE SCOPE

Future studies may improve the reliability of rainwater harvesting suitability analysis by adopting advanced multi-criteria decision-making techniques such as AHP, fuzzy AHP or Fuzzy Logic which can help reduce subjectivity in weight assignment and better represent uncertainty in decision making (Preeti et al., 2022). The inclusion of additional hydrological and planning related parameters such as groundwater depth, lineament density and proximity to water infrastructure can further improve the spatial accuracy of suitability mapping (Ouali et al., 2022). Field verification of high suitability zone can be used to validate GIS based model outputs and access on ground feasibility of proposed interventions (Waghaye et al., 2023). The adopted GIS based framework can also be extended to other regions with similar hydro-climatic conditions to support sustainable rainwater harvesting planning (Preeti et al., 2022).

REFERENCES

1. *Adham, M. Riksen, M. Ouessar, and C. Ritsema, "Identification of suitable sites for rainwater harvesting structures in arid and semi-arid regions: A review," Int. Soil Water Conserv. Res., vol. 4, no. 2, pp. 108–120, 2016, doi: 10.1016/j.iswcr.2016.03.001.*

2. *A. Adham, M. Riksen, R. Abed, S. Shadeed, and C. Ritsema, "Assessing suitable techniques for rainwater harvesting using analytical hierarchy process (AHP) and GIS techniques," Water, vol. 14, no. 13, Art. no. 2110, 2022, doi: 10.3390/w14132110.*

3. *K. S. Balkhair and K. Ur Rahman, "Development and assessment of rainwater harvesting suitability map using analytical hierarchy process, GIS and remote sensing techniques," Geocarto Int., vol. 36, no. 4, pp. 421–448, 2021, doi: 10.1080/10106049.2019.1608591.*

4. *K. Choudhury, C. K. Sarma, P. Barua, B. Baro, P. Bharali, J. Enghipi, and A. Jorhat, "Suitability classification for construction of rainwater harvesting systems using geospatial techniques in Lumbajong and Langsomepi watersheds, Karbi Anglong District, Assam, India."*

5. *Y. Debebe, R. Otterpohl, and Z. Islam, "Remote sensing and multi-criterion analysis for identifying suitable rainwater harvesting areas," Acta Geophys., vol. 71, no. 3, pp. 855–872, 2023, doi: 10.1007/s11600-022-00910-8.*

6. *T. A. Fetene, A. M. Kidanemariam, F. A. Menayehu, et al., "A GIS-based multi-criteria evaluation for rainwater harvesting suitability in Awi Zone, Northwestern Ethiopia," Discover Water, vol. 6, Art. no. 1, 2026, doi: 10.1007/s43832-025-00303-0.*

7. *A. S. Jasrotia, A. Majhi, and S. Singh, "Water balance approach for rainwater harvesting using remote sensing and GIS techniques in Jammu Himalaya, India," Water Resour. Manag., vol. 23, pp. 3035–3055, 2009, doi: 10.1007/s11269-009-9422-5.*

8. *S. H. Mahmoud and A. A. Alazba, "The potential of in situ rainwater harvesting in arid regions: Developing a methodology to identify suitable areas using a GIS-based decision support system," Arab. J. Geosci., vol. 8, pp. 5167–5179, 2015, doi: 10.1007/s12517-014-1535-3.*

9. *L. Ouali, M. Hssaisoune, L. Kabiri, et al., "Mapping of potential sites for rainwater harvesting structures using GIS and MCDM approaches: A case study of the Toudgha watershed, Morocco," Euro-Mediterr. J. Environ. Integr., vol. 7, pp. 49–64, 2022, doi: 10.1007/s41207-022-00294-7.*

10. *H. Prasad, P. Bhalla, and S. Palria, "Site suitability analysis of water harvesting structures using remote sensing and GIS: A case study of Pisangan watershed, Ajmer District, Rajasthan," ISPRS Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., vol. XL-8, pp. 1471–1482, 2014, doi: 10.5194/isprsarchives-XL-8-1471-2014.*

11. *P. Preeti, Y. Shendryk, and A. Rahman, "Identification of suitable sites using GIS for rainwater harvesting structures to meet irrigation demand," Water, vol. 14, Art. no. 3480, 2022, doi: 10.3390/w14213480*

12. *S. Roy, S. Hazra, and A. Chanda, "Identifying rainwater harvesting structure sites using MCDM-based GIS approach: A mitigation measure for drought in sub-humid red and lateritic zones of West Bengal, India," Arab. J. Geosci., vol. 15, Art. no. 784, 2022, doi: 10.1007/s12517-022-10077-7.*

13. *K. Tiwari, R. Goyal, and A. Sarkar, "GIS-based methodology for identification of suitable locations for rainwater harvesting structures," Water Resour. Manag., vol. 32, pp. 1811–1825, 2018, doi: 10.1007/s11269-018-1905-9*

14. *A. M. Waghaye, D. K. Singh, A. Sarangi, et al., "Identification of suitable zones and sites for rainwater harvesting using GIS and multicriteria decision analysis," Environ. Monit. Assess., vol. 195, Art. no. 279, 2023, doi: 10.1007/s10661-022-10801-6.*

15. *A. Waghaye, "Mapping of rainwater harvesting potential using fuzzy AHP and GIS in the Kanhar River catchment," Indian J. Soil Conserv., vol. 50, pp. 199–208, 2022.*