Roy *et al.*
*Bulletin of the National Research Centre* (2024) 48:32
https://doi.org/10.1186/s42269-024-01188-0

Bulletin of the National Research Centre

RESEARCH
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# Land use and meteorological influences on dengue transmission dynamics in Dhaka city, Bangladesh

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## Abstract

**Background** Dengue fever, a viral illness spread mostly by Aedes mosquitoes, continues to pose a substantial public health issue in Dhaka city, Bangladesh. In Dhaka, climatic and socio-demographic factors like population density affect the spread of dengue. The dengue indexes are greatest in the residential mixed zone. Numerous environmental parameters, such as temperature, relative humidity, rainfall, and the air pollution index, have been linked to mosquito larvae, and dengue prevalence is correlated with urbanization, decreased vegetation, and population expansion.

**Methods** By using an extensive dataset that encompasses a range of years, we use spatial and temporal analytic methodologies to investigate the correlation between land use attributes, climatic variables, and the occurrence of dengue fever. To better understand the dynamics of dengue, the built environment and climatic factors are treated as independent variables in this study. ArcPy is a Python package that facilitates here for geographic data analysis and ArcMap 10.7 also used for visualizing spatial data.

**Results** The results of our study demonstrate that land use significantly influences the spatial patterns of Dengue incidence in Dhaka city. The dengue hotspot Thana are identified and these are Badda, Jatrabari, kadamtali, Mirpur, Mohammadpur, Sobujbagh, Shyampur, Tejgoan, Dhanmondi and Uttara. All of these areas' population density and residential use as land use is higher than the other Thana of Dhaka city. There exists a significant correlation between climatic characteristics, such as temperature (0.25), rainfall (.803), specific humidity (0.74), relative humidity (0.76), wind speed (0.4) and Dengue incidence patterns. This research emphasizes the structural use and climatic relationship in Dengue epidemics, with climatic conditions playing a significant role as drivers of these variations.

**Conclusions** This research demonstrates the complex relationship between land use, meteorological factors, and the spread of Dengue fever in Dhaka city. The results of this study have significant significance for several domains, including urban planning, public health measures, and vector control tactics. A comprehensive understanding of the temporal and geographical patterns of dengue transmission might aid in the development of accurate and effective prevention measures intended to lessen the effects of dengue in cities, such as Dhaka.

**Keywords** Dengue hotspot zones, Dengue transmission and dynamics, Dhaka city, Land use, Meteorological factors, Structure use

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## Background

Dengue fever burden and transmission dynamics may vary as a result of climate change. Research indicates that the dengue virus may become less widespread as temperatures increase (Mendoza-Cano et al. 2023). However, under some temperature profiles, there is an increased risk of possible dengue epidemics; the biggest risk is associated with temperatures between 27 and 31 °C (Trejo et al. 2023). Climate change is likely to broaden the geographic range of dengue transmission, with temperature, relative humidity, and rainfall being significant climatic parameters associated with dengue transmission (Bhatia et al. 2022). Proactive steps can help reduce the health implications of climate change, which influence infectious illnesses in humans at different scales (Souza et al. 2021). Climate change is expected to have an impact on dengue infections in Bangladesh, where outbreaks might happen at any moment and the season could last all year (Paul et al. 2021).

A virus called dengue is carried by mosquitoes and has been reported to be present around the world, especially in South Asia and especially in Bangladesh. Every year, Bangladesh has had many dengue epidemics of differing severity. Bangladesh experienced its worst dengue epidemic to date in 2019, with a notable number of cases and fatalities (Kayesh et al. 2023). There are a number of variables, including geography, population density, and climate change, that affect the spread of dengue throughout South Asia, including Bangladesh (Islam et al. 2023). In Bangladesh, the dengue virus (DENV) is widely distributed and co-circulating in all four serotypes, which raises the possibility of developing severe dengue (Banerjee and Robinson 2023). Climate variables like temperature, humidity, precipitation, wind speed, and air pressure might affect the spread of dengue (Kamal et al. 2023). In order to stop dengue epidemics, vector control methods are essential, and Bangladesh has to develop better vector control plans (Miah et al. 2023). Controlling the spread of dengue in Bangladesh and other South Asian nations may be accomplished by comprehending the effects of climatic conditions and putting appropriate control measures in place.

Climate and the incidence of dengue are intricately linked. The most significant explanatory factors for the transmission of dengue virus (DENV) between vectors and human hosts are rainfall, temperature, and humidity, according to a meta-analysis of the literature (Depradine and Lovell 2004; Colón-González et al. 2013; Naish et al. 2014). The details of these interactions, however, differ greatly between locations and are still mostly unclear from the available research. Furthermore, a number of empirical research conducted in Asia and Latin America have cautioned that there may not be a linear link between precipitation and dengue prevalence since excessive rainfall might have a detrimental effect on vector reproduction (Halide and Ridd 2008; Wu et al. 2009). Furthermore, artificial water containers have a critical role in both dengue incidence and Aedes mosquito reproduction, particularly in metropolitan settings and in built up area (Islam et al. 2019).

Dengue, a viral disease transmitted by the Aedes mosquito, is mainly prevalent in tropical and subtropical regions of the globe (Nyenke et al. 2023). This highly infectious disease is caused by dengue virus that shows symptoms like fever, rash, and joint pain (Sinare and Barkade 2023). Without the need for an incubation period (Li et al. 2023), this dengue virus has not only been rapidly transmitted in tropical urban areas, but also in rural ones (Man et al. 2023), which is influenced by multiple factors, such as mosquito population density, climatic conditions, and population movement patterns (Zeng et al. 2023). Today, this potential worldwide epidemic (Mukherji and Kaushik 2015) is spreading from the USA to China, from Europe to Australia, and even in Japan, Colombia, and Venezuela (Aliaga-Samanez et al. 2021). In a nutshell, South America, Africa, and Southeast Asia are mainly the hotspots of dengue outbreaks, with over 105 million worldwide estimated dengue infections every year (Cattarino et al. 2020). Over 2.5 billion people across 100 countries around the globe are currently under threat of this dengue virus (Dehghani and Kassiri 2021), and Bangladesh, a Southeast Asian tropical country, is not an exception.

Once known as 'Dhaka Fever' (Kamal et al. 2023), dengue epidemiology in Bangladesh has exhibited a consistent pattern of increasing frequency and size of outbreaks and a gradual expansion in geographic scope since its initial recorded outbreak in 2000 (Hossain et al. 2023a). Currently, the incidence of the dengue virus is extensive across Bangladesh, substantially impacting morbidity and mortality rates (Bhowmik et al. 2023), especially in Dhaka (Alam 2023). According to the World Health Organization (2023), dengue is now an epidemic in Dhaka, and Dhaka city corporation has been the most severely affected among the areas in Dhaka division. Several researches have been conducted in Dhaka city to explore the reasons for the dengue outbreak in Dhaka city.

Kamal et al. (2023) explored that higher ground and air temperatures, lesser vegetation, water bodies, dense urban characteristics, relative humidity, and precipitation positively impact dengue, also argued by (Banu et al. 2014; Islam et al. 2021; Paul et al. 2018; Salje et al. 2016; Sharmin et al. 2015; Zahirul Islam et al. 2018). Hossain et al. (2023b) stated that maximum and minimum temperature, humidity, and wind speed have a positive relation with dengue, however, dengue cases decreased with higher levels of rainfall (Hossain et al. 2023b). Salje et al. (2016) also argued that most cases occur between June and November, with a strong correlation between increased rainfall and Dengue cases occurring two months later. Monthly precipitation days substantially correlate with dengue prevalence (Rahman et al. 2020). Dengue transmission in Dhaka is influenced by temperature fluctuations, and socio-demographic factors like population density (Sharmin et al. 2015). Haque et al. (2023) stated that the central business and residential mixed zone has the highest dengue indices, and age distribution is a highly significant risk factor. Paul et al. (2018) identified that tires, plastic drums, discarded construction materials, refrigerator trays, vehicle parts, container location, presence of vegetation, and availability of shade for containers significantly impact the abundance of dengue mosquitoes. Additionally, a notable increase in the prevalence of Aedes mosquitoes in low socioeconomic areas of Dhaka. (Paul et al. 2018).

According to Guo et al. (2023), in China, temperature, number of rainy days, pan evaporation, relative humidity, and sea level pressure have positive impact on dengue fever, and wind speed is a protective factor. In India, poorer, high-density areas, warmer temperatures increase the risk of dengue (Telle et al. 2021). Besides, both temperature and precipitation play crucial roles in virus development and mosquito population dynamics (Mutheneni et al. 2017). Ahmad et al. (2018) found that there were correlations between mosquito larvae and various environmental factors, including rainfall, relative humidity, temperature, and air pollution index, and dengue prevalence relate to urbanization, reduced vegetation, and population growth, but not water bodies in Malaysia (Zan 2015). Insufficient flood control and water disposal infrastructure can heighten the likelihood of a dengue outbreak, particularly in densely populated regions (Junaid Tahir et al. 2020). Ebi and Nealon (2016) also stated that global dengue risk is strongly influenced by local temperature, precipitation, urbanization, and socioeconomic factors with that urban expansion will increase the frequency and intensity of dengue outbreaks (Lindsay et al. 2017).

As there was not sufficient research on dengue of Dhaka city, besides, the dengue outbreak condition of Dhaka city is severe, this research aims to examine the factors influencing the transmission and spread of dengue fever in Dhaka. Specifically, it will investigate the relationship between meteorological factors and dengue, as well as the relationship between the built environment and dengue.

## Materials and methods

This research takes a quantitative approach, and it examines the meteorological data and Landuse based detail data of Dhaka city in order to better understand the dynamics of dengue (Table 1).

### Variables and methods of analysis

#### *Methods*

According to Codecademy Team (2023), Numpy and Pandas, are very powerful and open-source python libraries, used for data extraction and analysis in this research. Microsoft excel is used for data visualization. ArcPy is a Python package that facilitates geographic data analysis, conversion, management, and map automation using Python, is used for spatial analysis, besides, ArcMap 10.7 also used for visualizing spatial data. Jupyter Notebook is a web-based interactive computing platform and IDLE a Python's Integrated Development and Learning Environment both are used for scripting python language.

**Table 1** Variables and the research method

| | | Approach | Variables | Analysis | Data Source |
|---|---|---|---|---|---|
| Independent variables | Meteorological | Quantitative | Specific humidity at 2 m (g/kg) | The Pearson correlation coefficient* | https://power.larc.nasa.gov (September, 2022 to August, 2023) |
| | | | Relative humidity at 2 m (%) | | |
| | | | Precipitation (mm/day) | | |
| | | | Temperature at 2 m | | |
| | | | Land surface temperature (°C) | | |
| | | | Wind speed at 2 m (m/s) | | |
| | Built environment | Qualitative | Structure use | Descriptive statistics | Detailed area plan (2016–2035) |
| | | | Structure type | | |
| | | | Land use | | |
| Dependent variables | | | Number of dengue patients | | Directorate general of health services (DGHS) at https://dghs.gov.bd. (Accessed on 05 September 2023) |

*The Pearson correlation coefficient quantifies linear associations ranging from − 1 to 1. A value above 0.5 indicates a strong positive relationship, 0.3–0.5 suggests a moderate positive relationship, 0 to 0.3 implies a weak positive relationship, 0 means no relationship, − 0.3 to 0 indicates a weak negative relationship, and − 0.3 to − 0.5 signifies a moderate negative relationship, while below -0.5 is a strong negative relationship (Turney 2022)

### *Study area*

Dhaka city, a residence of 23,210,000 people (Dhaka, Bangladesh Metro Area Population 1950–2024 | MacroTrends 2024) is selected as the study area, where dengue is severely outbroken. For exploring the relationship between dengue patients and climate factors, Dhaka city is fully considered as a study area, and for the built environment, the study followed dengue hotspot zones (DHZ) explored by The Directorate General of Health Services (DGHS).

According to DGHS Fig. 1 illustrates the dengue hotspots in Dhaka city, which include Jatrabari, Mugda, Kodomtoli, Jurain, Dhanmondi, Basabo, Uttara, Mohammadpur, Mirpur, Tejgaon, and Badda (Dhaka Tribune 2023). The Thana boundaries, small jurisdiction boundaries of the dengue hotspot areas, are considered for spatial analysis, and the Thanas are Badda, Dhanmondi, Jatrabari, Kadomtoli, Mirpur, Mohammadpur, Sabujbag, Shaympur, Tejgaon, Uttara.

### *Data sources*

Several dengue data were collected from the website of the Directorate General of Health Services (DGHS) (dghs.gov.bd), where daily number of dengue incidents (patients) and daily deaths due to dengue diseases is published. Hospital-based data is provided within Dhaka city and district-based data is provided all over the country. This study collected the daily hospital-based data as the focus of this study was only Dhaka city.

The POWER Project of National Aeronautics and Space Administration (NASA) (https://power.larc.nasa.gov) is the source of Meteorological Data. Time-series data (daily meteorological data) was collected following the days of the dengue incidents.

## Results

### Monthly dengue cases

Monthly dengue cases, spanning from September 2022 to August 2023, an increasing trend in dengue cases, despite the relatively lower values in between. Even though number of dengue cases fluctuated in the beginning. But then exhibited a sharp increase starting from May 2023. In the graph, it is evident that dengue cases typically surge during the months ranging from June to November (Fig. 2).

### *Structure type*

Dhaka city possesses Pucca, Semi-pucca and also Katcha structures all around. It is evident that the dengue hotspot zones possess a significant amount of semi-pucca and Katcha structures. The percentage is highest in Kadamtali area which is 32.9% of semi-pucca and 32.58% of kutcha. Whereas lowest in Dhanmondi area, 27.3% of semi-pucca and 3.38% of kutcha structure (Fig. 3). On the contrary other areas of Dhaka, five areas were selected at random,

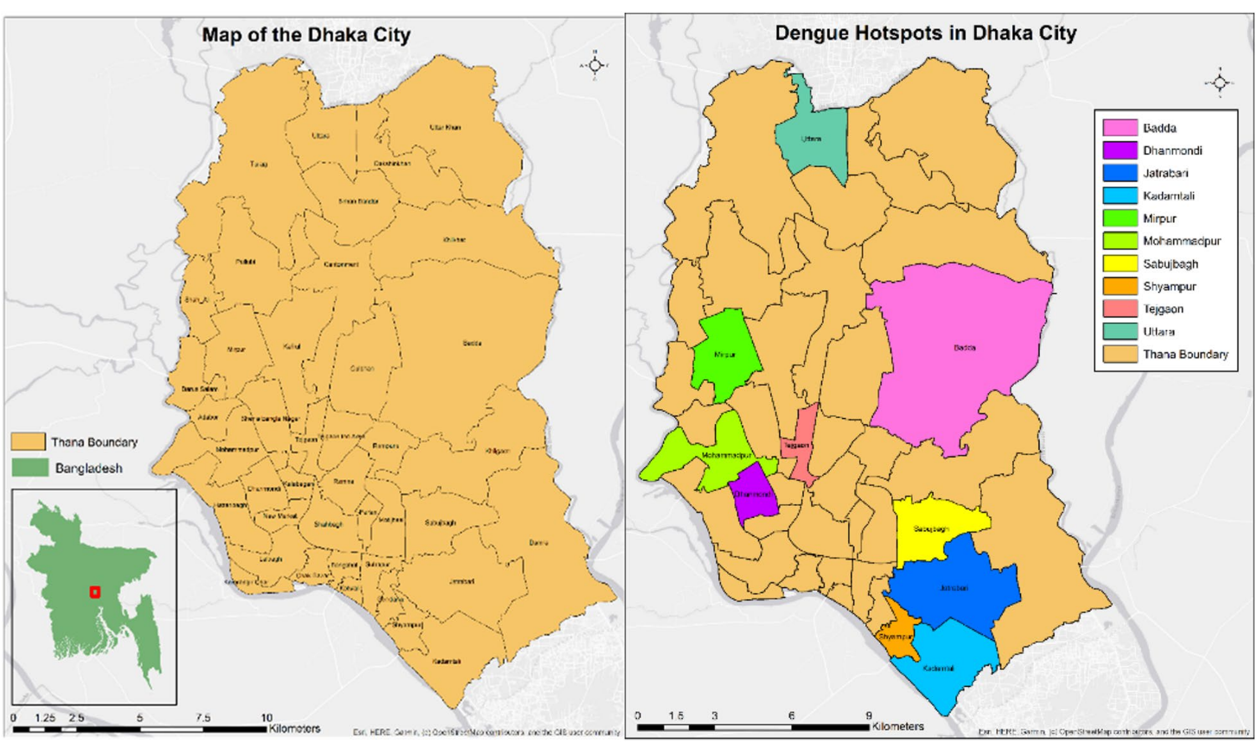


**Fig. 1** Map of Dhaka city with Thana boundaries and Dengue Hotspot Zones in Dhaka city

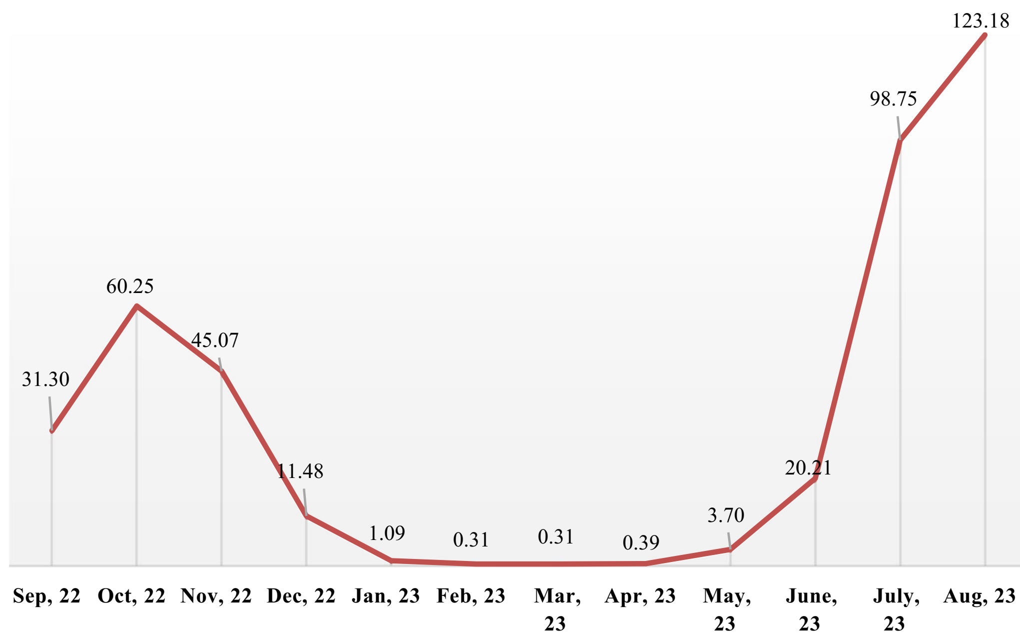


**Fig. 2** Dengue case timeline

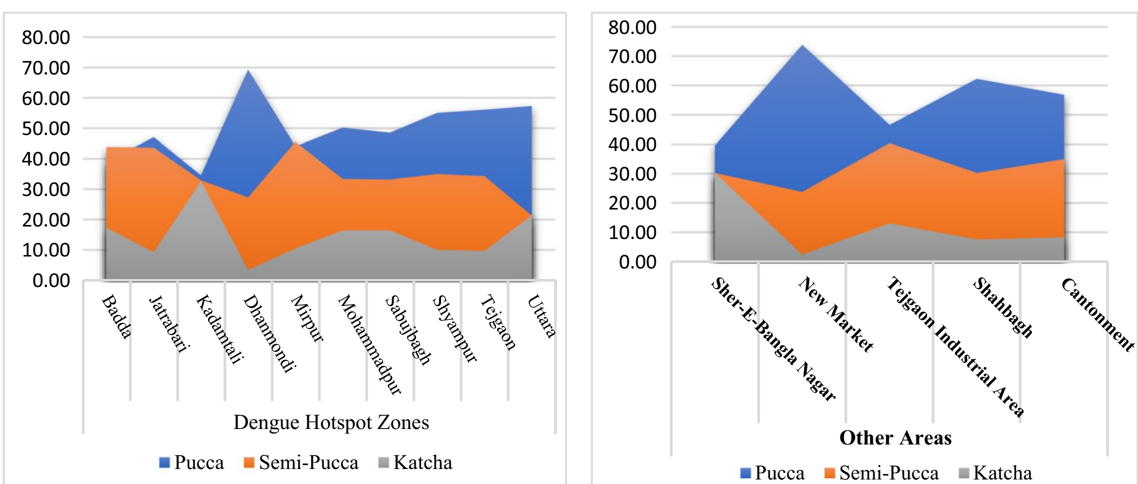


**Fig. 3** Structure type of dengue hotspot zones (left) and structure type of other areas (right)

shows a different picture having higher proportion of pucca structures than the other two categories (Fig. 3).

#### *Structure use*

Badda, Jatrabari, Kadamtali, Sabujbagh, and Shyampur have over 80% residential structures. Mirpur has 76.02% residential and 9.23% mixed-use, mostly residential-commercial. Dhanmondi, Mohammadpur, Tejgaon, and Uttara are around 70% residential, but also have 9.23%, 14.37%, 8.81%, and 7.87% mixed-use structures, respectively. Badda, Sabujbagh, and Shyampur have over 5% mixed-use structures. The various land uses (in percentage) in the dengue hotspot zones of Dhaka city are presented in Fig. 4. In dengue hotspots, residential use dominates, with mixed-use being mostly residential-commercial.

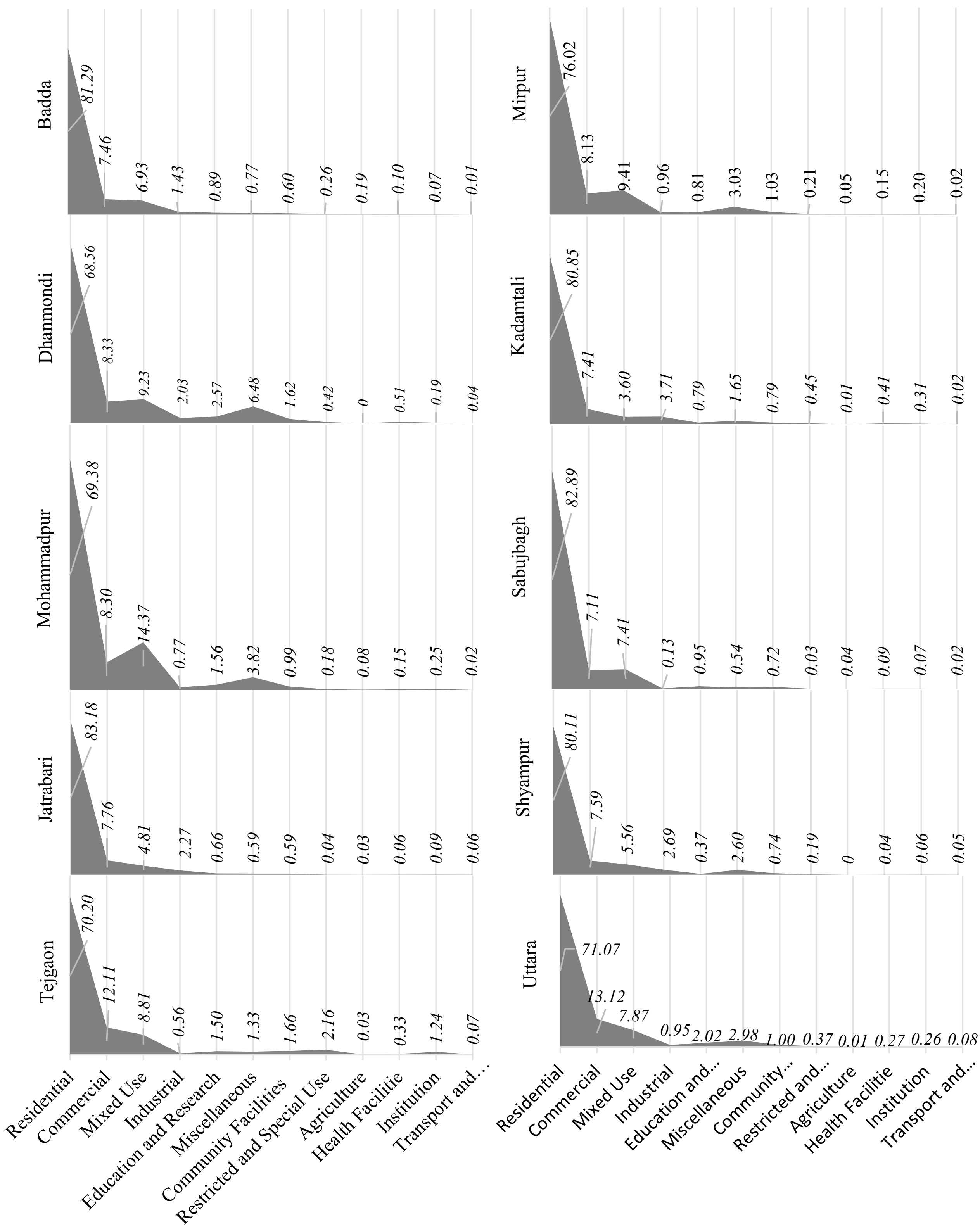


**Fig. 4** Structure use of dengue hotspot zones

Residential structure use in Sher E Bangla Nagar is 70% and Cantonment is 60%. Shahbagh, Tejgaon Industrial Area, New Market is less than 50%. There have significant number of different types of structures (Fig. 5).

Residential structure use in number is higher in dengue hotspot areas than in other areas. On the contrary commercial, mixed-use, institutional, health facilities, community facilities, education and research, agricultural, miscellaneous, transportation and communication, restricted and special use structures are high in number in other areas (Fig. 6).

***Land use***

Land use refers to the arrangements, activities, and inputs by people to produce, change, or maintain a certain land cover type (Wang et al. 2020). Natural land use refers to the existing land including the natural distribution and arrangement of vegetation, water bodies, and

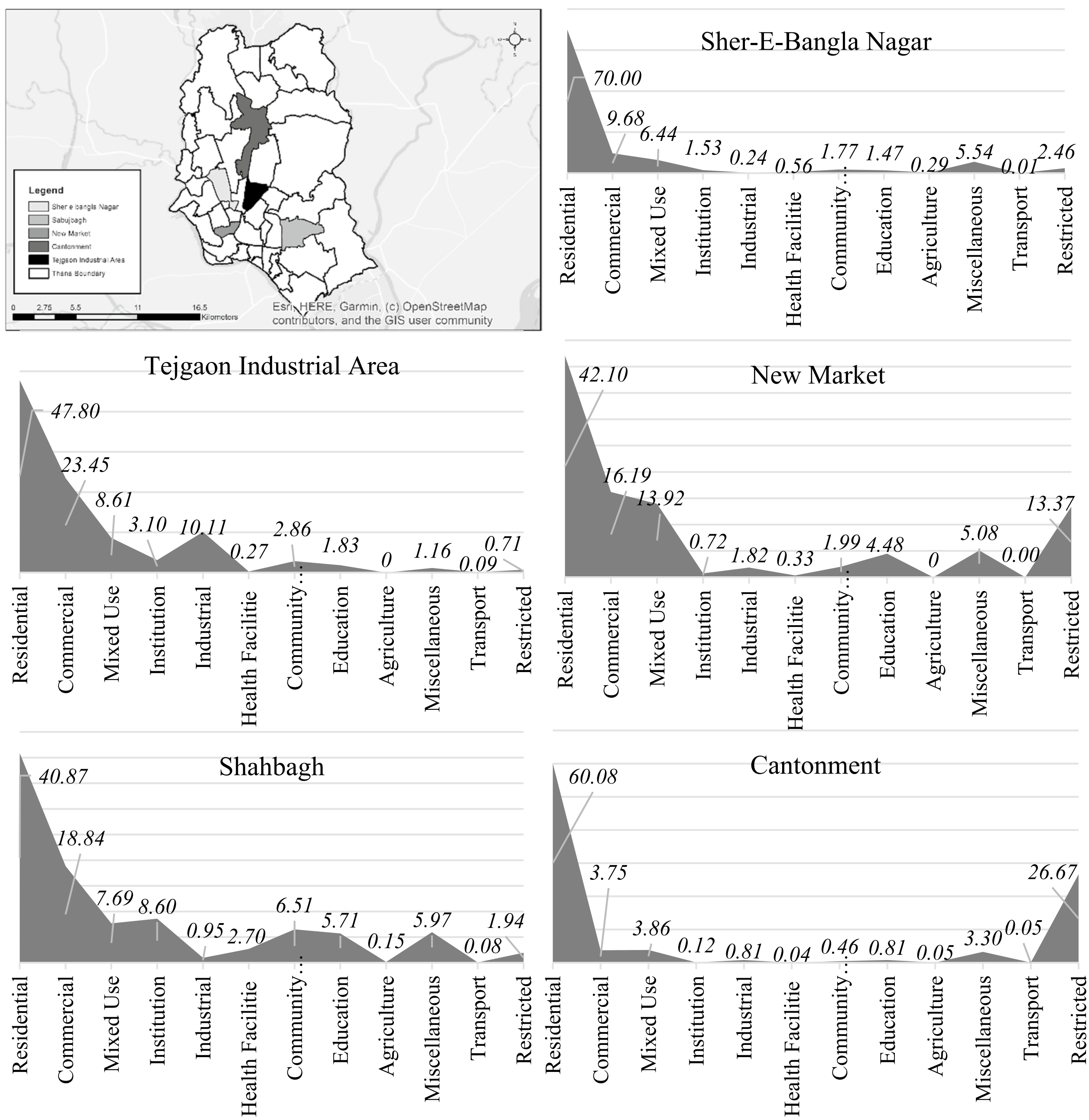


**Fig. 5** Structure use of other areas

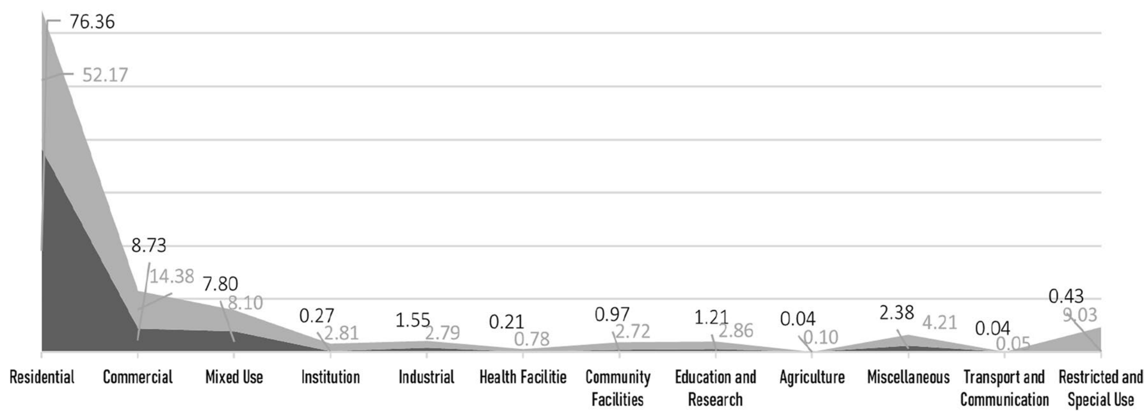


**Fig. 6** Structure use comparison of dengue hotspot zone vs other zones/area

other natural features on the Earth's surface. On the other hand, manmade land use refers to the manipulation of the land cover, such as agriculture, urbanization, infrastructure development, and industrial activities (Bondarenko et al. 2020; Haug 1997; Loenhart 2022). According to the Details Area Plan of Dhaka, within Dhaka city, manmade land use is divided into proposed road network, transportation and communication, overlay zone, rural settlement zone, administrative zone, institutional zone, general administrative zone, commercial zone, mixed-use zone, urban residential zone, and natural land use is divided into natural water body, natural water retention area, natural open space, natural flood flow zone (Rajdhani Unnayan Kartipakkha-RAJUK 2021).

The figure is divided into two broad categories of land use for dengue hotspot areas. The figures have been separated based on manmade land use pattern and natural land use characteristics. The first portion of the graph shows natural land use (left) in percentage and clearly states that there is no significant natural land use pattern in those areas as they are predominantly urbanized and built environments (Fig. 7).

The second portion of the graph shows manmade landuse in percentage. In terms of manmade land use, the graph highlights that "Urban residential Zone" occupies the highest percentage of land across all areas, followed by "Mixed use zone" as the second-highest. Notably, the "Mixed use Zone" combines predominantly residential and commercial units, with some also having industrial use (Fig. 7).

There is no particular land use is dominated in other areas. Each areas have its individual nature and residential land use is not predominant in New Market, Sher E Bangla Nagar, Tejgaon Industrial Area, Shahabag, Cantonment Thana (Fig. 8).

The amount of residential land use is higher in dengue hotspot areas than in other areas. Besides mixed land use percentage cannot be negligible, whereas in other areas mixed land use is lower than in dengue hotspot areas. In Dhaka city, most of the mixed land use contains residential-commercial type (Fig. 9).

## Dengue and climate factors

The meteorological information for the years 2022 and 2023 has been obtained. The dataset consisted of observations collected between September 2022 and August 16, 2023, spanning a total of 350 days. Specifically, there were 122 days of data from 2022 and 228 days from 2023. The average number of Dengue cases is 8593, with a standard deviation (SD) of 4811 for the year of 2022 in Dhaka and it is calculated for the month of September to December. The smallest number of cases recorded is 2665 in December, while the greatest number is 13,984 which were in October, 2022 (Table 2). According to Table 2, the greatest number of cases in Dhaka for 2023 is reported as 28,590 only for 17 days of August 2023. The dengue data displays the average daily confirmed cases, which amount to roughly 548 for the 47 days of July and August. Additionally, the table presents the daily average values for humidity at 2 m (g/kg), relative humidity at 2 m in %, precipitation (mm/day), wind speed at 10 m (m/s), temperature, earth skin temperature and wind speed at 2 m (m/s). Based on the data, it is evident that there is an increase in both relative humidity and precipitation from the year 2022 to the year 2023 (Fig. 10) when considering the same month for comparison analysis. Furthermore, there is a strong correlation between these meteorological factors and the incidence of dengue cases (Figs. 10 and 11). The findings indicate that the minimum recorded temperature in 2022 was 16.10C, while the maximum temperature was 29.90C and in 2023 was 16.20C, while the maximum temperature was 34.90C. Furthermore, the observed precipitation ranges from a low of 0 mm/day to

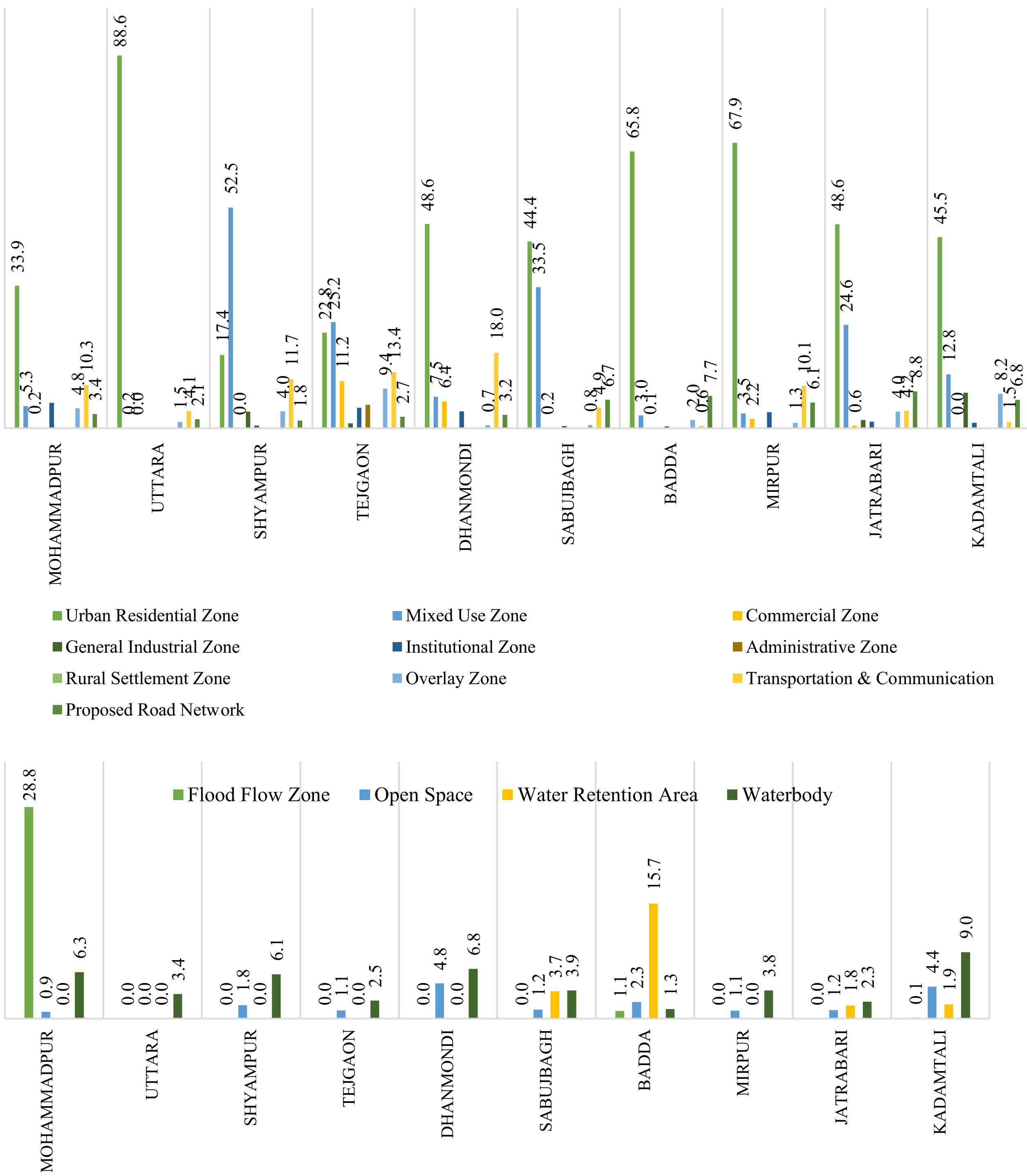


**Fig. 7** Land use of dengue hotspot zones

a high of 24.3 mm/day and 90.2 mm/day for the month of July and August, respectively, of 2023.

Correlation coefficients range from −1 to 1, where "−1" indicates a strong negative correlation, "1" indicates a strong positive correlation, and "0" indicates no linear correlation. Specific humidity, relative humidity and precipitation have strong positive correlation with number of dengue patients and wind speed has moderate positive correlation where land surface temperature and Air temperature have weak positive correlation (Fig. 11).

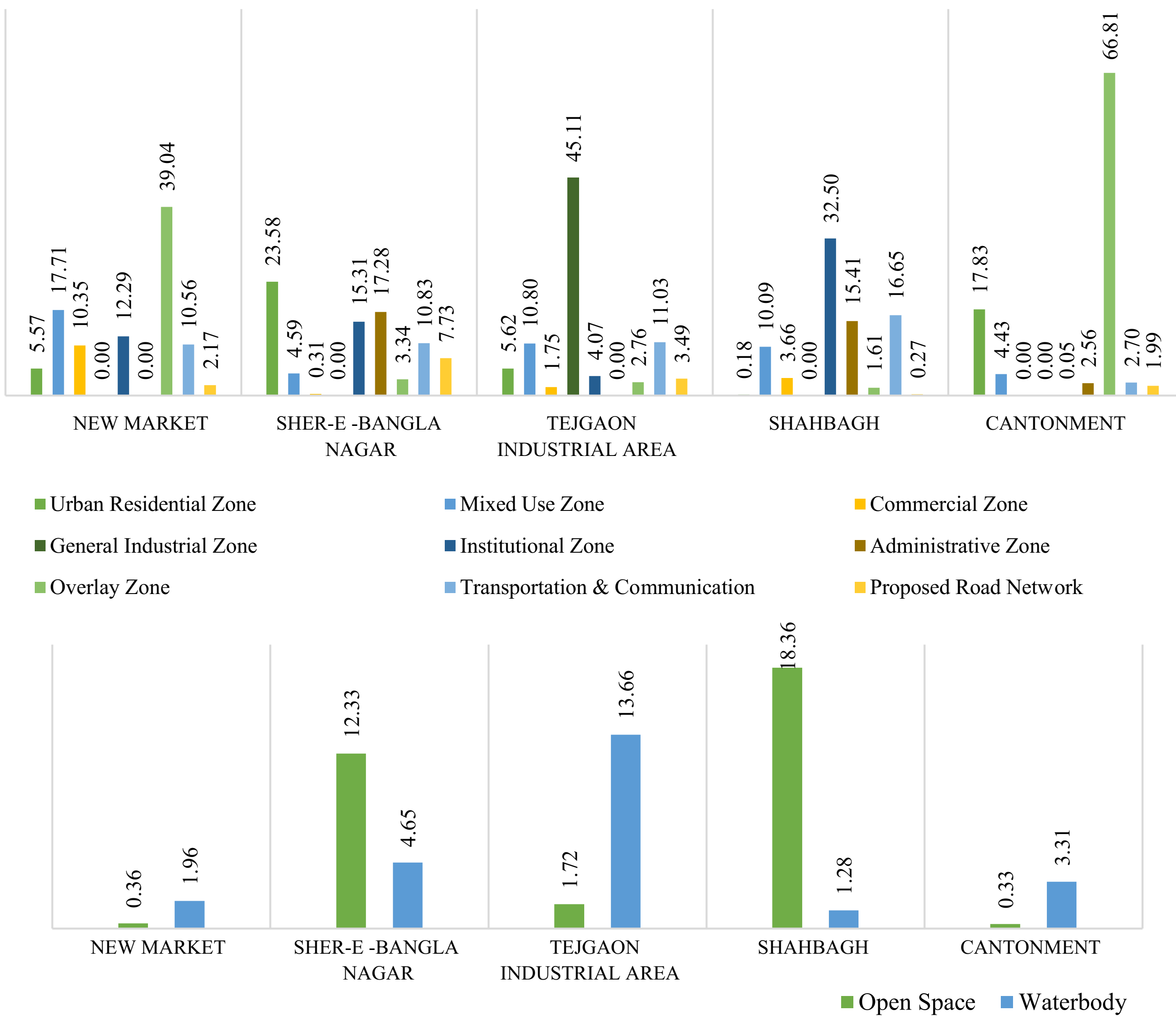


**Fig. 8** Land use of other areas

## Discussion

Dengue fever incidents were reported in Bangladesh from 1964 to 1999 when there was a noticeable increase in incidence that year, which signaled the beginning of a severe outbreak that resulted in 5551 (Salje et al. 2016; Yang et al. 2023) hospitalized cases and 93 deaths (Yunus et al. 2001). Major Dengue outbreaks continued to center on Dhaka, the country's capital, until 2021 (Hossain et al. 2022). According to surveillance data gleaned from hospital records, there were seven outbreaks in Dhaka city between 2000 and 2022—each with more than 5,000 hospitalized cases. After a period of relative inactivity, dengue cases started to increase once more in 2016. This culminated in the greatest outbreak on record in 2019, with over 100,000 hospitalized patients and 179 fatalities in the Dhaka metropolis (Hossain et al. 2020). Another significant epidemic was subsequently noted in 2021, with 28,429 recorded cases and 85 fatalities; however, the concurrent COVID-19 pandemic, especially the propagation of the Delta variety (Hossain et al. 2022), may have concealed the outbreak's real scope. Notably, with 61,732 cases and 281 deaths, the second-largest outbreak happened in 2022 (https://dghs.gov.bd).

All dengue outbreaks in Bangladesh since 2000 have predominantly taken place within the confines of Dhaka city (Salje et al. 2016). Changes in the seasonal distribution of dengue cases may be related to variations in the climate. Nevertheless, due to its central location and relative compactness and flatness, Bangladesh experiences little change in climate variables like temperature

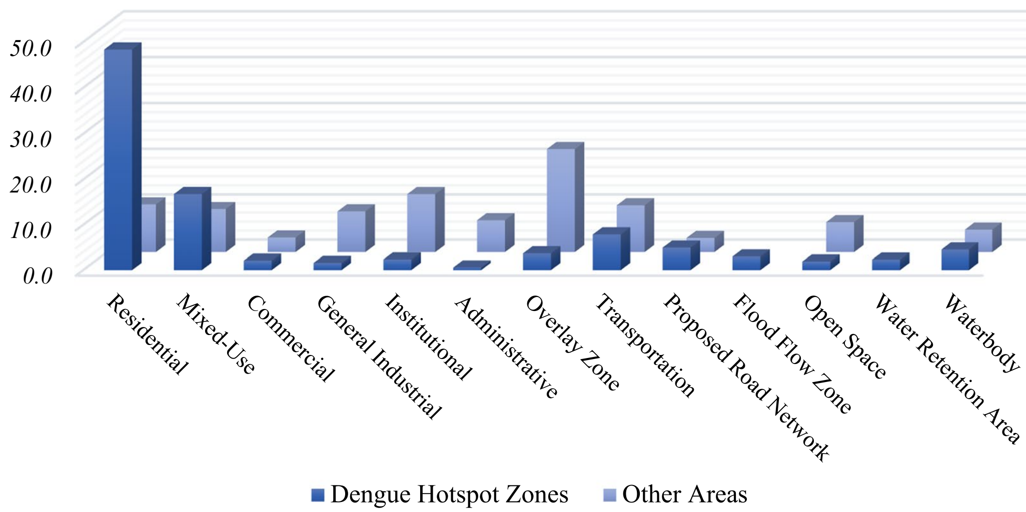


**Fig. 9** Land use comparison for dengue hotspot vs other area

**Table 2** Summary statistics of meteorological parameters and daily dengue confirmed cases in Dhaka

| | 2022 (*N* = 122) | 2023 (*N* = 228) | Overall (*N* = 350) | September, 2022 (*N* = 30) | July, 2023 (*N* = 31) | August, 2023 (*N* = 16) |
|---|---|---|---|---|---|---|
| *Specific humidity* | | | | | | |
| Mean (SD) | 15.8 (4.30) | 14.7 (5.26) | 15.1 (4.96) | 20.9 (0.701) | 21.4 (0.568) | 21.6 (0.601) |
| Median [min, max] | 15.1 [7.81, 22.2] | 14.2 [5.62, 22.9] | 14.2 [5.62, 22.9] | 21.0 [19.4, 22.2] | 21.6 [19.6, 22.2] | 21.6 [20.5, 22.9] |
| *Relative humidity* | | | | | | |
| Mean (SD) | 82.2 (6.40) | 64.2 (15.3) | 70.5 (15.5) | 88.0 (3.49) | 82.6 (3.39) | 88.0 (2.90) |
| Median [min, max] | 83.0 [64.8, 95.0] | 63.5 [35.1, 92.5] | 74.2 [35.1, 95.0] | 88.2 [80.1, 94.5] | 82.9 [71.8, 88.2] | 88.5 [80.7, 92.5] |
| *Precipitation* | | | | | | |
| Mean (SD) | 6.04 (15.6) | 3.49 (8.27) | 4.38 (11.4) | 10.9 (9.72) | 7.08 (6.03) | 19.5 (22.4) |
| Median [Min, Max] | 0.125 [0, 150] | 0.465 [0, 90.2] | 0.435 [0, 150] | 9.40 [0.370, 35.5] | 5.62 [0.320, 24.3] | 12.1 [3.31, 90.2] |
| *Temperature* | | | | | | |
| Mean (SD) | 24.1 (3.64) | 27.6 (4.69) | 26.4 (4.65) | 28.1 (0.656) | 29.7 (0.689) | 28.6 (0.687) |
| Median [min, max] | 24.4 [16.1, 29.9] | 29.0 [16.2, 34.9] | 27.6 [16.1, 34.9] | 27.9 [27.2, 29.9] | 29.7 [28.1, 31.0] | 28.5 [27.8, 30.4] |
| *Wind speed* | | | | | | |
| Mean (SD) | 1.55 (0.676) | 2.20 (0.994) | 1.97 (0.947) | 2.00 (0.846) | 2.81 (0.710) | 2.80 (1.10) |
| Median [min, max] | 1.44 [0.590, 4.95] | 1.99 [0.69, 5.85] | 1.65 [0.59, 5.85] | 1.68 [0.780, 3.88] | 2.91 [1.12, 4.04] | 2.82 [1.13, 5.16] |
| *Daily confirmed case (number of persons)* | | | | | | |
| Mean (SD) | 8593 (4811) | 7193 (11,659) | 7660 (9659) | 7265* | 22,921* | 28,590* |
| Median [min, max] | 8862 [2665, 13984] | 555 [71, 28590] | 13,678 [71, 28590] | - | - | - |

*Total cases of dengue patient

and rainfall (Khatun et al. 2020). Therefore, it is likely that increased temperatures contributed to the greatest outbreak in Dhaka and may have impacted the extrinsic incubation period (EIP) of the implicated mosquitoes. Seasonal dengue virus prevalence patterns are influenced by both climatic and ecological factors, according to several academic studies (Scott and Morrison 2004). It was also determined how different environmental conditions affected dengue outbreaks (Ahmad et al. 2018; Kesetyaningsih et al. 2018). Although it is well-recognized that climate conditions affect dengue incidence, the exact association between dengue fever and climatic patterns is unclear (Gubler et al. 2001). This intricacy results from the complex life cycles of the Aedes aegypti vector and its host, both of which are very susceptible to changes in climate.

The purpose of this study was to investigate the relationships between different meteorological and

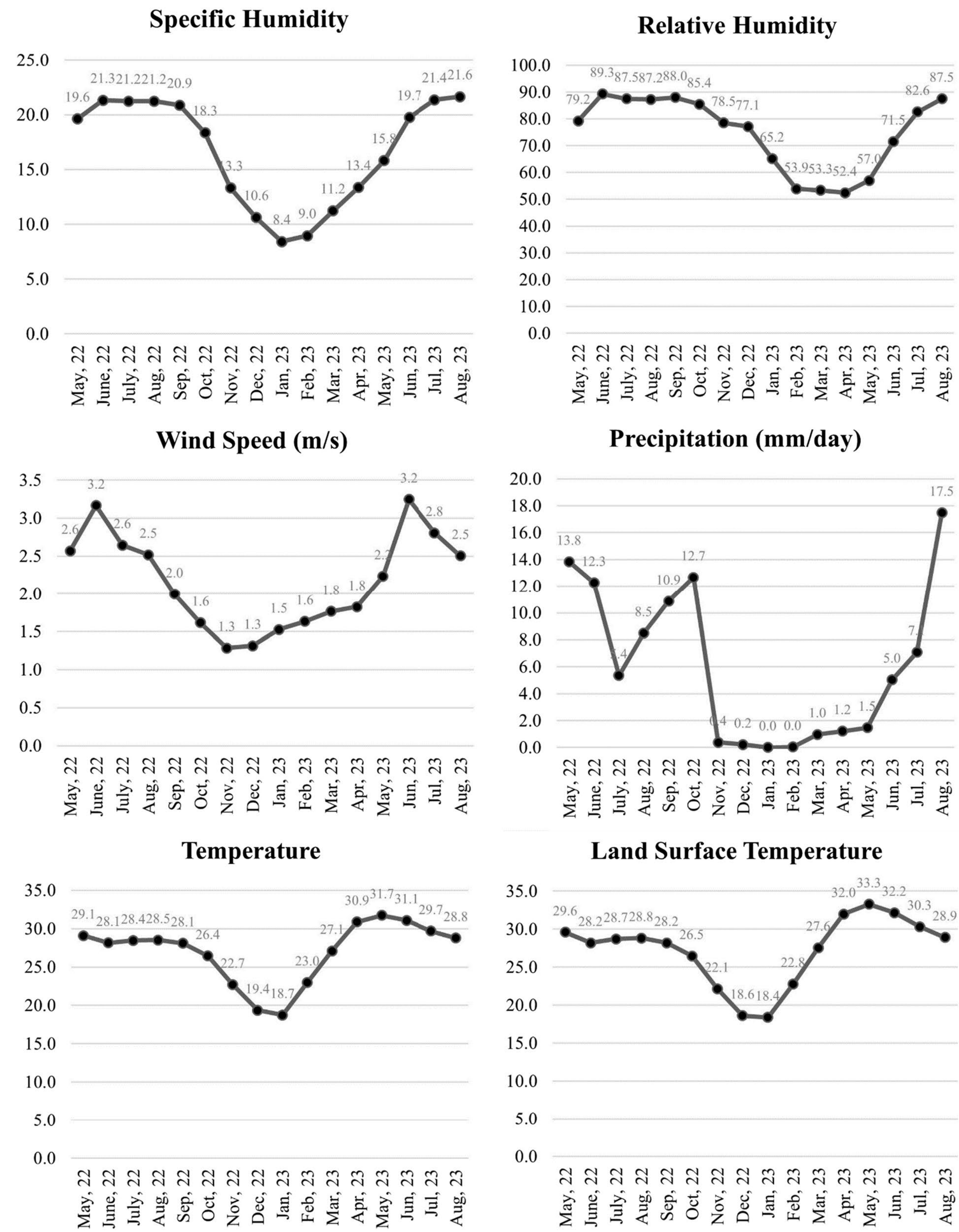


**Fig. 10** Insight of meteorological data

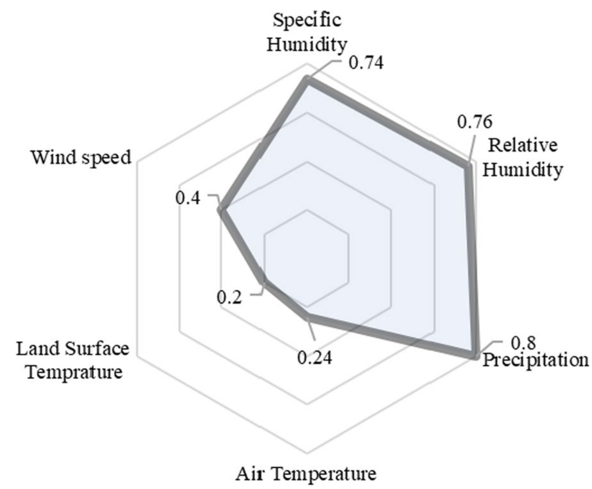


**Fig. 11** Correlation between meteorological factors and dengue patients

built-environmental variables and dengue cases in Dhaka, Bangladesh. Based on these discovered correlations, this research sought to demonstrate the local patterns of dengue risk. This research clarifies the intricate relationships between climatic variables and land use variables that affect dengue occurrences at the local level. Previous studies have consistently emphasized the important role that humidity, rainfall, and temperature play in dengue outbreaks. The impact of these climatic factors on the occurrence of dengue is further highlighted by this study. Understanding these trends can be essential for preventing future severe dengue epidemics in Bangladesh by giving time for preparation and response actions.

According to this study, the prevalence of dengue cases can be influenced by specific climatic conditions. A rise in global temperature may increase the prevalence of vector-borne diseases (Sutherst 2004). This research found a positive association between land surface temperatures and dengue cases. Furthermore, this study found a substantial positive correlation between dengue cases and relative and specific humidity. Higher relative humidity has been associated with more dengue cases during the monsoon season because the higher humidity during this time promotes the proliferation and survival of infected mosquitoes, which aids in the spread of the virus (Barbazan et al. 2010). Rainfall was also found to affect mosquito growth in both positive and negative ways. While excessive rainfall might ruin prospective mosquito habitats, adequate rainfall supplies standing water for mosquito breeding (Medicine 2008).

The study indicated that built environments, particularly compact residential areas, and non-agricultural areas had a significant impact on the occurrence of dengue cases. Increased dengue cases were found in locations with a greater proportion of human settlements, most likely as a result of these areas' higher population densities and thus higher rates of human biting. Because of this higher biting rate, Aedes mosquitoes have more chances to bite an infected person, contract the dengue virus, and then spread the infection to others (Scott and Morrison 2010). In locations related to human activity, manmade containers were found to hold Aedes mosquito habitats, with variations noted among different types of human settlements (Vanwambeke et al. 2007). These results emphasize the value of considering land use factors when strategically designing and implementing vector control approaches.

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These results emphasize the value of taking land use factors into consideration when strategically designing and implementing vector control approaches.

## Limitation

Although this study offers a wide range of consequences, it is crucial to recognize its inherent limitations. The main goal of the study is to understand the relationship between meteorological factors, land use features, and dengue incidence in the Dhaka area. However, a significant flaw in the dataset's design and underlying record-keeping and reporting processes is implied by the dataset's significant gaps and incompleteness. These flaws could be a result of structural problems, including an incomplete system for monitoring or a lack of awareness on the part of the responsible authorities.

## Conclusions

The annual recurrence of dengue fever in Bangladesh, particularly in the urban areas of the metropolis of Dhaka, represents a continuing threat to the populace and presents ongoing difficulties for healthcare officials. Furthermore, it is important to highlight that different environmental, land use, and socioeconomic conditions that are favorable to the spread of this disease are widespread to differing degrees across the country. As a result, proactive forecasting of possible dengue outbreaks provides a crucial method for authorities to create and put into action effective plans in response to unforeseen emergencies. In this situation, incorporating health-related factors into land use planning is a determined effort to address the needs of the public's health. The main goal of this study is to clarify the intricate relationships between meteorological factors and land use patterns in relation to dengue prevalence in the urban environment of Dhaka, Bangladesh. Notably, land surface temperature, humidity, and precipitation are found to have a clearly positive impact on dengue incidence rates, while wind speed is found to have a clear and significant adverse impact. The designation of compact residential and commercial areas, structural typology, and the intended purpose of structures are only a few examples of the land use elements that have been found to exhibit a saliently positive association with dengue incidence. The conclusions drawn from this study hold enormous potential for guiding the development of policy, particularly in the context of developing a climate and land use-based early warning system customized to the distinctive epidemiological landscape of Bangladesh.

### Abbreviations

| | |
|---|---|
| DENV | Dengue virus |
| DGHS | Directorate General of Health Services |
| DHZ | Dengue Hotspot Zones |
| EIP | Extrinsic Incubation Period |
| NASA | National Aeronautics and Space Administration |
| RAJUKL | Rajdhani Unnayan Kartipakkha (Development Control Authority of Dhaka) |
| SD | Standard deviation |

### Acknowledgements

The authors would like to acknowledge the support of department of Urban and Regional Planning of Jahangirnagar University, Bangladesh.

### Author contributions

SR and AB planned the research, completed the data analysis, and wrote the article. MMR conducted the study and contributed to the manuscript's writing. MMR and MTAS reviewed the article and gave important suggestions. SA provided field support and contributed with the survey. MMR contributed to the data and results analysis. The final text was reviewed and approved by all writers.

### Funding

There are no external funding sources for this study. The authors used their own resources to conduct the study.

### Availability of data and materials

The data will be given to anyone who requests for it.

## Declarations

### Ethics approval and consent to participate

Not relevant. The current study refrained from incorporating personal information or concerns.

### Consent for publication

There are no personally identifiable materials in the manuscript, including interviews, recordings, or other personal matters. As a result, providing consent regarding personal matters is not applicable. Furthermore, the authors' have no conflicting interests that prevent them from publishing this research.

### Competing interests

The authors affirm that no conflicts of interest exist.

Received: 30 December 2023 Accepted: 13 March 2024
Published online: 19 March 2024

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## Publisher's Note