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Implications of meteorological and physiographical parameters on dengue fever occurrences in Delhi

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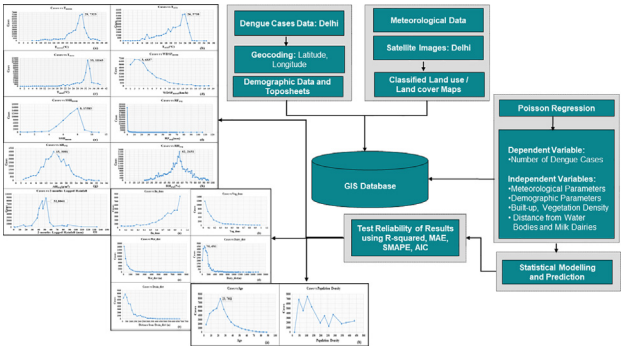
HIGHLIGHTS

- Extracted environmental, physiographic and socio-economic factors using remote sensing and GIS techniques
- The analysis of monthly reported DF cases revealed a strong seasonal distribution of DF cases
- Relationship between causative factors and DF incidences has been developed using Poisson regression analysis
- Critical range of causative factors favouring high number of DF incidences has been found
- Statistical significance of established mathematical equations has been determined

GRAPHICAL ABSTRACT



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ABSTRACT

Dengue Fever has become an increasing public health concern around the world due to its serious health consequences including death, lack of effective vaccine and specific treatment. Influence of area specific meteorological and physiographical characteristics on the spread of infectious diseases need to be studied to understand spatial-temporal aspects of infectious diseases in a particular area. Mathematical relationships between various explanatory variables (causative factors) and Dengue Fever incidences have been established to quantify and prioritize the influence of various factors. So that, effective health care services could be provided in these areas. The study successfully explains the occurrences of Dengue Fever in Delhi in term of geo-spatial phenomena/variables. Meteorological data of 13 stations in Delhi at hourly temporal scale for a period 2006–2015 have been used along with multi-spectral satellite data. Data on reported cases of Dengue Fever on daily basis and for a period of ten years from 2006 to 2015 have been obtained for Delhi. Python modules have been developed to extract values of geospatial parameters and to perform Poisson regression. To assess the accuracy of developed Poisson regression based equations, r-squared and error statistics have been calculated. Results indicate strong association of Dengue Fever incidences with temperature, humidity, wind speed, sunshine hours, built-up and vegetation density and distance from dairy locations, waterbodies and drainage network. Further, critical ranges of various parameters favouring high number of Dengue Fever incidences have been determined. These findings have significant public health implications for control and prevention of Dengue Fever incidences in Delhi city and surrounding region. Occurrences of Dengue Fever incidences are found to be highest in the month of September and October. These months represent transition period from rainy season to winter season. It is recommended that further study should focus on detailed analysis of causative factors in this period.

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1. Introduction

Recent studies conducted by World Health Organization (WHO factsheets, 2016) have shown that vector-borne diseases account for >17% of all infectious diseases, causing >1 million deaths annually. The WHO regions of Southeast Asia and western Pacific constitute nearly 75% of the current global burden of dengue (Murray et al., 2013). DF and Dengue Haemorrhagic Fever (DHF) have been reported from 24 states in India with thousands of cases and thousands of deaths annually (Sivagnaname et al., 2012; Palaniyandi, 2014; Palaniyandi, 2014). In 2015, Delhi has recorded its worst outbreak since 2006 with over 15,000 cases (WHO factsheet, 2016). Delhi has humid and warm climate which provides a favourable environment for Aedes mosquitoes breeding (Vikram et al., 2015). The continuous occurrence of DF outbreaks and the increasing severity of the disease have raised the need for in-depth understanding of causative factors related to DF incidences to develop effective dengue surveillance and deploy control measures.

In the present century, vector-borne diseases are resurging as a result of changes in environmental characteristics, public health policy, demographic changes, vector resistance to insecticide and drug, a shift in emphasis from prevention to emergency response and due to genetic changes in pathogens (Dar and Wani, 2010). According to Gubler (2002), the resurgence of Dengue Fever (DF) epidemic is due to five major reasons namely a) demographic changes, b) social change, c) agricultural changes, d) changes in pathogens and e) deficiencies in public health services. Demographic changes include global population growth, population movements, unplanned and uncontrolled urbanization. Social changes include human encroachment on natural disease foci, transportation and containerized shipping. Agricultural changes include changes in land use land cover (e.g. deforestation), introduction of irrigation system and deforestation. Changes in pathogens are due to increased movement of humans, animals and genetic changes leading to increased epidemic potential. Lastly, deficiency in public health services includes lack of effective vector control, deterioration of public health infrastructure to control vector-borne diseases, inadequate surveillance of disease and prevention programs. Recent research work has highlighted that climate patterns such as temperature and rainfall trends can have direct effects on vector-borne disease transmission (Patz et al., 1998; Bambrick et al., 2009; Johansson et al., 2009b; Chowell et al., 2011; Colón-González et al., 2013; Parham et al., 2015;

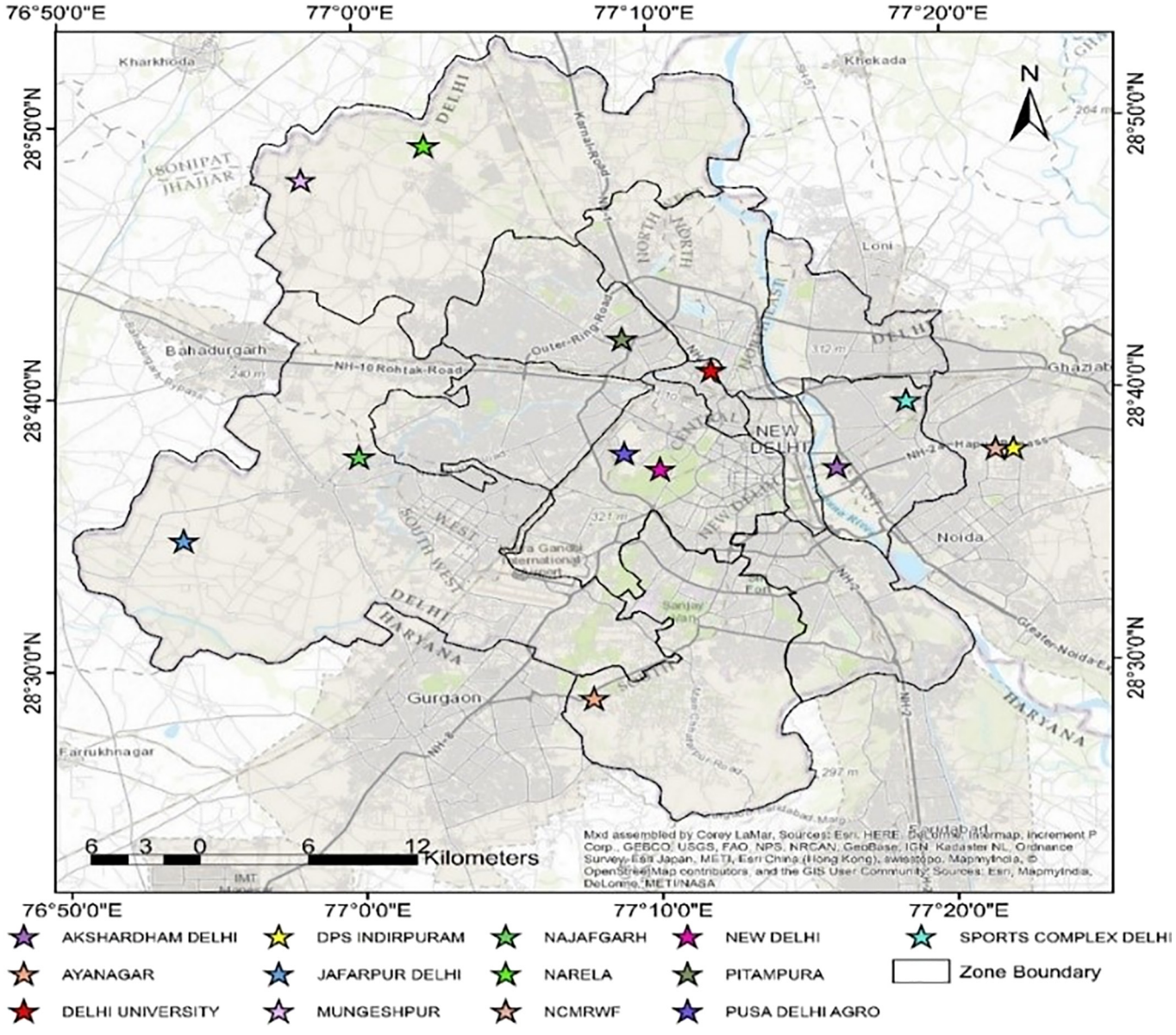

Fig. 1. Location of weather stations in Delhi (zone boundary is shown by black color and weather stations are shown by star shape).