ABSTRACT

Malaria is one of the most dangerous vector borne diseases, causing more than one million deaths every year. Many researchers envisioned the control and elimination of malaria by inventing new drugs, developing newer strategies and by developing various models. In the process, many new concepts and complexities have been introduced. Still these inventions and new models are like tip of the iceberg compared to the existing complexities involved in malaria.

In India, malaria is a major public health problem and it contributes significantly to the overall malaria burden in Southeast Asia. To find a solution to the problem, mathematical models do help explain the dynamics of such infectious disease and can facilitate comparisons among competing control strategies that can inform policy decisions. Further to strengthen the prevention and control measures, this study has been carried out in order to develop appropriate modelling approaches of forecasting malaria transmission.

The study specifically has been aimed to develop three possible approaches to model and forecast the propagation of malaria with respect to the climate change variables. The first approach is to predict the variation in vector density with respect to climate variables in the subtropical climatic zones of lower Himalayan regions having increasing altitudes using Genetic Programming (GP). The study is done at three locations namely Raikhalkhatta, Bhorsa and Jyadi. Models have been developed based on the vector density as indicator. Calibration and validation of the simulated vector density indicated very good significance levels. To assess the impact of temperature and rainfall on the
vector density sensitivity analyses also have been done for all the locations. The analyses showed the variation in vector density on increasing and decreasing the temperature.

The second forecasting model has been developed through another novel approach by coupling the Fire Fly Algorithm (FFA) and Support Vector Machines (SVM) to determine the malaria transmission at two locations in the plains of Rajasthan under arid and semi-arid climatic zones. The performance of SVM models depend upon the appropriate choice of SVM parameters. In this study FFA has been employed for determining the parameters of SVM. In addition, three more forecasting approaches are developed by employing Support Vector Machines (SVM), Artificial Neural Network (ANN) and Auto Regressive Moving Average (ARMA). At both stations malarial incidences have been computed using SVM-FFA, SVM, ANN and ARMA models. Simulated and actual malaria incidences values are compared. SVM-FFA model performed best out of four models, and showed very good significance level for the simulated malaria incidences on comparing it with the actual incidences. Box and Whiskers Plot has been used to find out the normalized residual errors to compare all the above algorithms. Sensitivity analyses also have been done which showed that there is variation in incidences on increasing and decreasing the temperature.

The Anopheles mosquito is one of the major vectors of malaria. Anopheles culicifacies species play a major role in spreading malaria in Asian countries, especially in Indian subcontinent. Hence, thirdly a mathematical model has been worked out to understand interactions of entomological and climatic parameters of malaria transmission. MATLAB has been used to develop this deterministic model, in the process three major steps are followed. First of all the endogenous variables, which have significant influence on the
parasite transmission cycle, are identified and their relationship as a function of temperature is determined. Secondly, vector ecology, and entomological parameters are identified in order to determine exogenous parameters, which have direct influence on the malaria transmission. Finally a set of Coupled Ordinary Differential Equations is solved in order to determine the malarial incidences using Fourth Order Runge-Kutta Methods. The developed model is validated using already published data. Results match quite well with the data.