Summary
SUMMARY

Malaria is a serious epidemiological challenge in India and several deaths are reported annually. Malaria parasite *Plasmodium falciparum*, in presence of many efficient malaria vectors, such as *Anopheles dirus, An. minimus* and *An. fluviatilis* contribute majority of the malaria cases. In addition, various socio-economical factors have influenced malaria prevalence, mainly in the tropical countries, where malaria has been linked to the socio-economic variables which determine the malaria risk among vulnerable population groups. Mosquito vector control has been relied largely on the use of insecticides across the endemic countries since many decades. DDT and synthetic pyrethroids derived products are used in indoor sprays and bed net impregnation. Geographical information system (GIS) has recently emerged as an important component of public health projects as it aids in visualizing and analyzing geographic distribution of disease with respect to time and space.

In the present investigation spatial-temporal distribution of malaria was carried out in the two endemic districts Udalguri and Sonitpur of Assam using GIS. The epidemiological data from 2006-2010 was collected and the sub-centre wise base maps of parasitological indices, such as Annual Parasite Incidence (API) and *P. falciparum (Pf)* proportion were prepared for each year. Based on the conditions of *Pf >30%* and *API >5* consistently during the years 2006-10, the sub-centres were depicted as malaria hotspots. Insecticide resistance was monitored in four villages in Tezpur area of Sonitpur district and four collection sites in Orang area of Udalguri district of Assam. Adult mosquitoes were collected with CDC light traps and hand operated aspirators and identified morphologically following the standard mosquito identification keys and nomenclature. The collected females were assayed for diagnostic doses of DDT (4%), deltamethrin (0.05%), malathion (5%) and lambda-cyhalothrin (0.05%) using the standard WHO method. Orang PHC of Udalguri district emerged as potential malaria hotspot where in addition to the focused malaria intervention, identifying
socio-economic and demographic factors associated with the malaria risk was important to tackle malaria. In the current study, the selected household heads of villages in Orang PHC were interviewed to assess the potential influence of demographic factors, socio-economic status, knowledge, awareness and education on the occurrence of malaria. Altogether 71 household heads representing 385 individuals were interviewed and the information about the personal attributes, knowledge of malaria and socio-economic parameters were recorded in a well structured questionnaire, printed in English and Assamese (local) languages.

The study depicted that in Udalguri district the number of sub-centres (SCs) having API >5 increased from 72 in 2006 to 75 in 2008 and number decreased to 55 in year 2009 to 3 in 2010. Thirty five SCs reported API in the range of 2-5 in 2006 which increased to 36 in 2010. On the other hand, number of SCs having 30-70 % Pf decreased from 34 to 27 in 2006 to 2010. The Pf% > 70 was raised to 26 in 2010 as compared to 16 in 2009. The sub-centres with API >5 was mainly concentrated in the Udalguri PHC, whereas, high percentage of Pf was in the sub-centres of Orang PHC. Five SCs namely, Pachimpotla in Khairabari PHC; Jaygyapur, Kadabil, Bahadur Adarsha in Orang PHC and Gitibari in Udalguri PHC were identified as malaria hotspots. In Sonitpur district SCs with API in the range of 2-5 were decreased from 52 in 2006 to 19 in 2010. The number of SCs reported API >5 were also declined to 6 in 2010 as compared to 72 in 2006. The SCs with Pf% in the range of 30-70 showed a decreasing trend with 95 in 2006 to 32 in 2010 and 46 SC’s have Pf% > 70 in 2006 as compared to 40 in 2010. Two SCs namely, Tinsuti in Biswnath Charali PHC and Dhankhana in Dhekiajuli PHC were depicted as malaria hotspots. In Tezpur area, total 7,201 mosquitoes were collected from four study villages, which includes five genera, Anopheles (n=2,727), Culex (n=3,264), Armigeres (n=307), Mansonia (n=866) and Coquillettidia (n=37). Nine species of Anopheles mosquitoes were identified as, An. vagus (n=1509), An. crowfordi (n=71), An. barbirostris (n= 41), An. maculatus (n=5), An. culicifacies (n=61), An.
philippinensis (n=62), An. annularis (n=966), An. aconitus (n=1), and An. subpictus (n=11). In Orang area, 2,017 mosquitoes falling under seven genera; namely Anopheles (7 species), Culex (4 species), Armigeres (1 species), Mansonia (2 species), Stegomyia (1 species) and Neomelaniconion (1 species) were collected from four collection sites. Anophelines accounted for 66.2% of the total mosquito collection with 66.8 per trap night density. The Anopheles species encountered were An. vagus (n= 624) which was the most predominant species of all collected mosquito species, An. barbirostris (n=28), An. maculatus (n=4), An. culicifacies (n=7), An. fluviatilis (n= 14), An. annularis (n=651), An. subpictus (n=8). An. vagus and An. annularis were the two known malaria vectors which were prevalent in good numbers in the study area therefore used in the resistance assay. In Tezpur and Orang areas, An. vagus and An. annularis were DDT resistant in all the study villages, except in Balitika, where resistance was suspected in An. vagus. An. vagus was completely sensitive to deltamethrin, whereas resistance was suspected against lambdacyhalothrin in all the study locations. However, An. annularis was susceptible to deltamethrin and lambdacyhalothrin except in Udmari and Balitika, where suspected resistance status was recorded. Against malathion, An. annularis in Udmari and Rupkuria villages and An. vagus in Udmari village were found suspected to have developed resistance, whereas, complete susceptibility has been observed in both species in the remaining study locations. There were high KDT50 and KDT95 values of DDT as compared to other tested insecticides in all survey sites. The varying pattern of insecticide resistance with species and region in the study demonstrates that insecticide resistance in mosquito is a complex and dynamic process and knowledge on insecticide resistance will be necessary to guide an efficient use of insecticides in both public health and agriculture. Out of 71 household heads interviewed, 70.4% (50/71) were males and the median age was 35 years. About half (54.9%, 39/71) of the participants had a history of malaria during the last two years, of which 64.1% were males, while 35.9% were females.
Of the total population surveyed, 46.5% were poor having a monthly income of < 2000 INR, 49.3% lived in bamboo houses and 35.2% lived at a distance of >3 km from the nearest health centre. The number of participants with malaria history decreased with increasing monthly income. Malaria occurrence was higher among the households living in bamboo houses (69.2%) as compared to Kucha houses (20.5%) built of mud and Pucca houses (10.3%) made of concrete. No significant association was observed between education level and malaria occurrence. The participants who did not use bed nets regularly reported high occurrence of malaria infection as compared to those who use bed nets every day.

The hotspots obtained using GIS immediately draw the attention onto the most endemic areas, which could be treated as priority areas for surveillance and monitoring of malaria. This study, although limited to district level, but can serve as a model for larger area to highlight malaria hotspots, to allocate resources and to monitor the pace of control programmes, which is not otherwise feasible. Present results confirmed the development of DDT resistance in tested known malaria vectors prevalent in the study area therefore, control programmes employing DDT as residual insecticide may not achieve satisfactory results. The visual maps for vector distribution and insecticide susceptibility of known vectors in a large area may be useful for better communication and targeting the vector with suitable insecticide even at local level. Although malaria incidences depend on various variables, the present study has identified that variables related to poverty, poor health infrastructure and awareness about malaria are important factors in determining the risk of malaria.