Discussion
5.1. Spatial distribution of malaria in Udalguri and Sonitpur districts

North-eastern states of India are malaria endemic and Assam is the major constituent state that alone accounts for 70% of total population contributing >50% of reported malaria cases in the northeast India. Inspite decades of attempted control, malaria still is a major impediment for socio-economic development of the region. The disease is unevenly distributed across the state and associated with varying intensity of transmission and associated risk factors. Since malaria distribution is not homogeneous, effort needs to be expanded towards defining local spatial distribution of the disease precedent to deployment of intervention (WHO, 2004). If the parameters determining transmission are to be harnessed effectively for decision making and objectively plan, execute, monitor and evaluate viable options for malaria vector control (Smith et al., 2005), they must be well organized, analyzed and managed in the context of a GIS based decision support system (Daash et al., 2009; Hemingway et al., 2006).

Mapping malaria cases can help health authorities to understand more about spatial distribution of the disease as well as its temporal occurrence in their respective areas. The information disseminated in the present study will be helpful in providing a guideline for organising well focused control programs and preparing health facilities based on the requirement of an area of interest. Many studies conducted in different endemic countries have continuously used the GIS technique for the analysis of spatial health related data, predicting outbreaks and guiding control interventions. It can be a useful tool in both developed as well as in the developing countries for analyzing the spread of diseases. This tool is useful for management strategy to allocate resources and preparing the needs for control of disease in high risk areas of disease. GIS also enables
GIS has introduced new dimensions to the understanding, prediction analysis and dissemination of spatial relation between disease, time, and space (Connor et al., 1997; Snow et al., 1998). It allows the integration of geographical referenced data, together with local knowledge in relational databases to accurately display complex interaction in simple formats (Daash et al., 2009). The use of these data sets in a GIS platform provides an opportunity to integrate current information, local knowledge and historical trends in a manner that draw attention to the areas that require change due to associated problems and options for action. This makes GIS a tool not simply for data analysis, but also for management of information and making decision which assists in policy formulation for the disease control (Booman et al., 2003). Another advantage is that once GIS infrastructure is established, it can be easily used for mapping of any disease such as dengue, filaria, Japanese encephalitis and chikungunya. The integration of operational and logistical data for malaria control program planning with epidemiological data serves to strengthen both epidemiological analysis and planning and execution of control programs.

In India, malaria control strategy in a year (y) for upcoming year (y+1) is based on the data of last year (y-1). Therefore, past year’s malaria data analysis is important for effective control programme in the upcoming year. In the present study geographical distribution of malaria in Udalguri and Sonitpur districts has been discussed at the sub-centre level from the 2006 to 2010. The distribution pattern of malaria in the study area is useful for the implementation of situation-specific malaria control strategies. Mapping of malaria risk areas can readily help to find out malaria hotspots along with
geographic locations to facilitate health authorities in proper resource allocations for malaria prevention.

The high malaria incidence in Udalguri and Sonitpur districts could be attributed to prevailing malariogenic conditions as well as the low socio-economic status of the population. Further, the frequent movement of non immune individuals including military, paramilitary and migrant labours engaged in various development projects manifolds the malaria risk (Dhiman et al., 2010a; Patra and Dev, 2004). The districts reports high API and Pf cases because most of the villages are near foothills and have very scanty health infrastructure due to poor communication and difficult terrain. In such endemic areas, although adhering to the National Malaria Eradication Programme (NMEP) of India guidelines, including > 10% annual blood examination rate (ABER) and regular residual spray, if API is > 2% is compulsory, but practically seems to be difficult.

In Udalguri district 54% of total population is estimated to be living below the poverty line and is dominated by various tribal communities. The tribal people are suffering from geo-political neglect, high level of poverty and belief in traditional systems of disease treatment (Chaturvedi et al., 2009). The state has high malaria cases annually, which may be because it shares long and porous international border with neighbouring countries. The population of border areas are considered to be at greater risk of acquiring malaria infections and believed to be infection reservoirs for persistent transmission of malaria due to intermixing of non-immune and immune population (Dev et al., 2006a; Prasad, 2009). In Sonitpur district, malaria incidence has come down in past few years due to intensive control efforts at various levels, which include improvement of health centres facilities, recruitments and training of health staffs, new
drug policies for malaria, use of rapid diagnosis kits and awareness on malaria (Nath et al., 2013).

The hotspot identification in the present study can be used in the prediction of malaria occurrence during the coming years based on the extrapolation from the past and present malaria patterns. In Madhya Pradesh of India, the focused malaria control was taken up on priority in the hot pockets identified in GIS platform by national vector borne disease control programme (Srivastava et al., 2009). This type of studies have been proved to be helpful to provide basic knowledge of malaria risk and hence to focus the control efforts toward vulnerable population (Omumbo et al., 2005). The present study integrated with variation in geographical, seasonal, weather and socio-economic factors can be utilized to establish a causal relationship between these factors and malaria occurrence. The similar kind of analysis model has been used to reduce malaria related infection and death in Africa (Idown et al., 2009). A recent study conducted in south India has used temporal analysis of malaria prevalence and showed that there had been a decreasing trend in the overall malaria prevalence over time with a distinct seasonal pattern (Kumar et al., 2014). The study used hotspots for understanding the malaria prevalence spatially. The study found that the identified hotspots were heavily affected by malaria. The malaria hotspots enabled to find that hotspots emerged suddenly in some areas where these were not observed previously. Previous studies have used GIS using spatial, geographic, demographic and social variables to understand the malaria load in an area and also to find the spatial risks of many vector borne diseases and effectiveness of medical services (Bejon et al., 2010; Coleman et al., 2009; Ernst et al., 2006; Haque et al., 2012; Messina et al., 2011; Moreno et al., 2008; Winters et al., 2010; Zhang et al., 2012). GIS method was successfully used in
analysing the temporal shift of malaria prevalence in the endemic villages of African countries (Yeshiwondim et al., 2012). Many studies argue that identification of hotspots followed by hotspots targeted intervention could be useful in resource allocation and in malaria interventions where adequate resources are available (Kumar et al., 2014; Nath et al., 2013; Yadav et al., 2012).

The geospatial technology has also been useful as part of integrated surveillance response approaches for malaria elimination in Solomon Islands and Vanuatu. Based on GIS, the developed system was focused on providing a user friendly operational tool to support detailed malaria surveillance response that was based on routinely collected malaria data (Kelly et al., 2013). Accurately identification of malaria transmission foci and support for timely interventions is crucial to ensure that the transmission at local level can be effectively stopped. However significant challenges remain as the effectiveness of the GIS based surveillance-response system is dependent upon timely and accurate reporting of malaria cases at a specified health centre level.

The mapping of malaria endemic locations and risk areas based on eco-geographic and demographic data helps health authorities to understand the human and environmental factors that determine malaria transmission patterns. This understanding is critical for effective allocation of resources to malaria prevention. Health data alone may not be reliable enough to guide malaria programming, but if combined with environmental, population and geographic data through GIS, a picture of malaria risk areas and possible options may emerge.

The maps generated from GIS based malaria incidence mapping of Udalguri and Sonitpur districts at the sub-centre level were effective in communicating the main findings with the district health authority and local health workers and provided
essential information in targeting limited financial and human resources for the control of malaria within the province.

5.2. Mosquito distribution and insecticide resistance

Vector control comprises of an important part in the global strategies for the control of major vector borne diseases, especially malaria, dengue, leishmaniasis, and chagas disease (Townson et al., 2005). Since the discovery of DDT and other organochlorine insecticides in 1940s, vector control has largely relied on the action of chemical insecticides to kill mosquito vectors to prevent transmission of disease pathogens among the humans. It has been well documented by the World Health Organization and in numerous scientific reports worldwide that the use of synthetic insecticides can dramatically reduce the risk of insect-borne diseases, particularly in the case of mosquito-borne diseases (Hemingway and Bates, 2003; WHO, 2006b). These insecticide chemicals have demonstrated great potential in mosquito vector control operation because of their high level of activity at extremely low doses, which quickly immobilizes and kills the insects and at the same time very low toxicity to human and other animals (Kumar et al., 2009; Zhong et al., 2013). The use of insecticide treated bed nets (ITNs), long lasting insecticide treated nets (LLINs) and indoor residual spraying (IRS) has evidenced the decline in malaria in the areas where predominant malaria vectors tend to bite and rest indoors (DFID, 2010).

The extensive uses of insecticides have raised concern over the development of insecticide resistance and adverse effects on the environment and human health. Gene conferring insecticide resistance have been spreading rapidly among the vector populations, particularly in malaria and dengue vectors (Ranson et al., 2010, 2011). In India, DDT and malathion have been in use for the past two to five decades in vector
control programmes and later synthetic pyrethroids were introduced for IRS in areas with multiple insecticide-resistant vectors, and for the treatment of mosquito nets, ITNs and more recently for manufacturing of LLINs. Development of resistance in mosquito vectors may jeopardize the vector control efforts, thereby necessitating the update information on vector mosquito distribution, their resistance level and changing trends of resistance in target species in order to guide the insecticide use in malaria control programmes in the regions of interest. WHO recommended, tube and cone bioassays on sprayed surfaces and substrates to monitor the susceptibility status of the target vectors are effective tools to assess the efficacy of various insecticides used in vector control interventions.

The updated knowledge of spatial distribution and diversity of mosquito vectors across the endemic areas is inevitable for effective planning and better implementation of the intervention measure. The present study revealed the presence of twenty one mosquito species in the study villages around Solmara in Tezpur area of Sonitpur district and sixteen species in Orang area in Udalguri district. Nine species belonging to Anopheles genera (An. vagus, An. crawfordi, An. barbirostris, An. maculatus, An. culicifacies, An. philippinensis, An. annularis, An. aconitus and An. subpictus were found and identified in four villages around Tezpur area, while in Orang area, seven species in Anopheles genera (An. barbirostris, An. maculatus, An. culicifacies, An. fluviatilis, An. annularis, An. subpictus were identified. In the current study, known malaria vectors were collected in two ecologically distinct malaria endemic areas of Assam, where malaria transmission is predominantly supported by An. dirus, An. fluviatilis and An. minimus mosquito species. However recent studies conducted in Assam and adjoining Bangladesh have evidenced the role of An. annularis, An.
culicifacies, *An. philippinensis* and *An. vagus* in malaria transmission (Alam *et al.*, 2010; Bhattacharya *et al.*, 2010; Dhiman *et al.*, 2012; Prakash *et al.*, 2004). The study has indicated that many known malaria vectors were abundant in both the study areas, however did not report even a single specimen of established vectors *An. minimus* and *An. dirus* (Das *et al.*, 2004, 2011; Dev *et al.*, 2010; Sarma *et al.*, 2012). Both these vectors have been responsible for continuous spread of malaria in the region, but surprising results of the present study indicate that the other malaria vectors of comparatively lesser epidemiological importance as thought previously might have taken over malaria transmission in absence of the well established vectors. A recent study conducted in Balipara PHC of Assam have found *An. annularis* harbouring both *P. falciparum* and *P. vivax* and its density outnumbered the density of *An. minimus* (Dhiman *et al.*, 2012). *An. culicifacies*, although comes in lower counts but have strong anthropophilic character and malaria transmission potential in the sub-urbs of the region (Dhiman *et al.*, 2012). Further, *An. nivipes* and *An. vagus* have also been found positive for sporozoite in different areas of north-eastern India (Bhattacharya *et al.*, 2010; Prakash *et al.*, 2004).

Presently, *An. annularis* and *An. vagus* were recorded in large number in areas where malaria is still endemic and many cases are reported annually (Nath *et al.*, 2013; Rabha *et al.*, 2012; State malaria data, 2012-13; Yadav *et al.*, 2012). Although both these species are primarily considered to be zoophilic and exophilic in nature, they have been considered to be opportunistic in the host selection for blood meal and are thought to maintain malaria transmission in the region (Dhiman *et al.*, 2012; Prakash *et al.*, 2004). Large number of specimens of these two species was collected indoor resting which indicate that both of these might be shifting its exophilic and exophagic
behaviour to endophilic and endophagic. A latest study conducted along Assam-Meghalaya border indicated the *An. annularis* was preferred to rest indoor and a considerable proportion was found fed on human blood (Dhiman *et al.*, 2014). In the study areas, in recent years there has been tremendous deforestation and new resettlements are upcoming rapidly. The forestland which provides favourable breeding habitats for *An. dirus* and *An. minimus* has been significantly reduced during the last few years (Nath *et al.*, 2012). Therefore disruption in the ecology of these two vectors might have led other anopheline species such as, *An. annularis, An. vagus* and *An. philippinensis/nivipes* to establish themselves as major species owing to the vast paddy cultivation in the area.

Insecticide resistance studies were conducted for two known malaria vectors, namely, *An. vagus* and *An. annularis*, which were collected in good number, *An. annularis* is a known secondary vector in the region and *An. vagus* is primarily a vector of local interest and many blood feeding studies have indicated that throughout south-east Asia *An. vagus* fed primarily (over 90%) on cows and water buffalos and was usually ranked the least attracted to humans of all the *Anopheles* tested (Bruce-Chwatt *et al.*, 1966; Reid, 1961, 1968; Rao, 1984). However, over time evidences has increased indicating that this species serves as a secondary malaria vector under unusual circumstances that includes dense concentration of humans in association with low numbers or absence of bovids or primates (Alam *et al.*, 2010; Amerasinghe *et al.*, 1999; Baker *et al.*, 1987; Maheswary *et al.*, 1994; Prakash *et al.*, 2004). These areas included Thailand, Kampuchea, Bangladesh, Sri Lanka and some parts of India. Verhaeghen *et al.* (2010) considered *An. vagus* a potential malaria vector in the Mekong region (Kampuchea, Laos and Vietnam) during their assessment of vector resistance against
insecticides. Manguin et al. (2008) noted that it is a confirmed or secondary vector of malaria in East Timor. All this findings in these studies usually occurred when well recognized vectors were uncommon or absent. A similar condition was found in villages around Tezpur area and Orang area, where the survey was carried out for the first time to find the resistance status of these two known malaria vectors.

The present study indicates that there is widespread of DDT resistance and probably low level of resistance against pyrethroids and malathion among the known malaria vectors in the study areas. Many studies have demonstrated the development of resistance to DDT and synthetic pyrethroid among mosquito vectors in various region of India (Bhatt et al., 2012; Dhiman et al., 2010b, 2013; Gunasekaran et al., 2005; Mittal et al., 2002; Sharma et al., 2012; Singh et al., 2002). In the north-eastern region of India, DDT has been used in residual spray for many years and deltamethrin treated bed nets have been recently introduced by the public health department and provided free of cost in limited numbers to the villagers. Malathion is organophosphate compound and used largely in fogging operations to control mosquitoes. Lambda-cyhalothrin is another class of pyrethroids, which are used widely as agriculture pesticide in many agrarian belts of Assam.

In Tezpur and Orang areas *An. vagus* and *An. annularis* were found DDT resistance in all the study villages except in Balitika, where resistance was suspected in *An. vagus*. DDT resistance in *An. vagus* has also been reported in many south Asian countries including, Laos, Cambodia and Thailand (Bortel et al., 2008). *An. vagus* was completely sensitive to deltamethrin, whereas resistance was suspected against lambda-cyhalothrin in all the study locations. However, *An. annularis* was susceptible to deltamethrin and lambda-cyhalothrin 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.

The results indicate that the malaria vectors tested against all the four insecticides do not follow similar trend in exhibiting complex insecticide resistance behaviour and displayed variations even in closely located areas. The high KDT$_{50}$ and KDT$_{95}$ values of DDT as compared to other tested insecticides might be due to the fact that DDT has been used for many years, which have lead to the development of resistance among the mosquito species in various parts of Assam (Dhiman *et al.*, 2013; Sarkar *et al.*, 2009a, b). Further, the extensive use of insecticide in agriculture is also a major factor contributing to resistance development among the mosquito vectors (Dhiman *et al.*, 2010b; Phukan *et al.*, 2004). The knock down values are largely associated with the level of use of an insecticide, which would lead to possible resistance in the mosquito species (Kamau and Vulule, 2006). Many studies have revealed that knock down resistance mechanism is one of the most important forms of resistance, which occurs when the level of insecticide detoxifying enzyme is elevated in the mosquito (Roberts and Andre, 1994; Sarkar *et al.*, 2009a). The insecticide resistance is a complex mechanism and depends upon the different physiological condition of insect. Many studies have shown that use of different insecticides may accelerate cross resistance among different insecticide classes (Bielza *et al.*, 2007).

The insecticide resistance database consisting of data from different areas and displayed using online geospatial application may be useful in resistance monitoring. There is an urgent need to identify malaria vectors and test their susceptibility status
from different areas. It is obvious that for concerted interventions, the resistance data for each of the malaria vector species at local level needs to be monitored and communicated effectively. Resistance maps using GIS collate insecticide resistance data and make it readily available in easily understandable format for malaria vector control staff. The maps would allow assessment of the geographic extent and frequency of resistance monitoring for potential vectors, insecticide classes used, trends in resistance status and mechanism of resistance. Such easily digestible information may used to pinpoint major gaps in insecticide susceptibility monitoring, as well as to ascertain the up-to-date status on resistance. The extracted GIS maps can not guide a specific insecticide for use in the field, which largely depends on many factors including availability, cost, legislations and suitability (Knox et al., 2014). However, the maps can highlight target areas where sufficient data is either available or missing. Visual maps are important for monitoring resistance developed and spread over a period of time and devising control strategy accordingly. For example, if an area report high resistance to pyrethroids class of insecticides, the decision may be taken to switch over to carbamate or organophosphate compound is as per global plan for insecticide resistance (GPIRM) recommendations (WHO, 2012b). GIS maps can also be used to suggest for increased resistance monitoring in areas where high resistance have been identified and also be employed to determine if there is any change in insecticide resistance status over a period of time after specific control interventions (Knox et al., 2014).

The varying pattern of insecticide resistance with species and region demonstrates that insecticide resistance in mosquito is a complex and dynamic process. Knowledge on the factors which determine insecticide resistance will be necessary to guide an efficient use of insecticides in both public health and agriculture. Furthermore,
trends in resistance status should be carefully monitored mainly in malaria endemic areas and impact of existing vector control tools on resistant population should be assessed. A base line data on insecticide resistance is available for the study areas, which enable to follow trends in susceptibility status in the region and which will serve as basis for further resistance management for all known malaria vectors.

5.3. Socio-economic factors and malaria risk

Though substantial progress has been made in controlling malaria, still approximately 1.3 billion people continue to be at risk in the south-east Asian region. Ten of the eleven member nations of WHO-SEA region are malaria endemic contributing 15% to the global malaria burden (WHO, 2013). Inspite of killing countless people, malaria is an enervating disease that creates massive socio-economic burden globally mainly for poor people living in areas with limited access to health facility (Sachs and Malaney, 2002). Udalguri district is a malaria prone area, reporting API of >10 in majority of the health sub-centres (SCs) in the recent years (Yadav et al., 2012). Studies have estimated that 54% population of Udalguri district living below the poverty line and dominated by tribal communities. The tribal people are suffering from neglect in the developmental process and still prefer in traditional systems of disease treatment (Chaturvedi et al., 2009).

The results of malaria prevalence in both the sexes were similar to the previous studies conducted in the region (Dhiman et al., 2010b; NVBDCP, 2010; Rabha et al., 2011). Females are generally more vulnerable to malaria due to many household requirements, which make them more exposed of acquiring malaria infection (Ayele et al., 2012). Poverty was associated with the malaria prevalence in the study population. The better-off group reported lower level of malaria prevalence than poor. Many studies
have regarded malaria as a disease of the poor, which could be substantiated by noting that malaria concentration is higher in poorest continents and countries (Amegah et al., 2013; Ayele et al., 2012; Sharma, 2003; WHO, 2007; Worrall et al., 2005). The poor section of the society has comparatively less access to antimalarial and antimosquito measures, since they cannot afford personal protection measures, clean environment and are particularly vulnerable to the impact of ineffective diagnosis and treatment due to financial and cultural implications. Bamboo houses and more number of mosquito bites were positively associated with the malaria prevalence. It is most likely that poorly constructed bamboo houses might have a number of gaps and holes through which vector mosquito could enter easily. Further, these gaps provide passage through which human host odour could pass to the nearby mosquitoes making them more vulnerable to receive mosquito bites. A recent study in Laos suggests that good quality houses could reduce disease transmission by reducing human-mosquito contact (Hiscox et al., 2013).

There was strong association between common knowledge and awareness about malaria and prevalence of malaria among the study participants. The participants who satisfactorily responded to questions regarding malaria were less affected by malaria as compared to those who had poor knowledge about malaria. Knowledge and awareness has significant influence in malaria control. Evidences have suggested that individual knowledge, awareness and beliefs affect the malaria prevalence. The misconception and beliefs about malaria among some communities continuously battle with the correct scientific information and pose major set-backs in malaria control (Alemu et al., 2011; Dhiman, 2009; Hiscox et al., 2008). The distance from the households to the nearest health facility was impending factor for malaria prevalence. Many previous similar studies have reported that distance to the health centres influenced the treatment seeking
behaviour of individual, compounding the malaria situation (Lowassa et al., 2012). The distance to the health centre could be regarded as a factor for health facility accessibility for which the cost is met by the patients themselves. The findings suggest that the household members whose houses are near to the health centres will have more and timely access to the health care as compared to those whose houses are far away from the health centres. Further the households who lived close the health centres have more knowledge and awareness because they have more and regular interaction with the health staff.

The study suggests that the number of mosquito bites received by participants influenced the malaria prevalence. Higher the number of mosquito bites per day, more was the risk to get malaria infection. The risk of contracting malaria is proportional to the number of potentially infectious mosquito bites they receive. Studies have indicated that malaria transmission is amplified if mosquito bites are more. Humans who receive more mosquito bites might infect a large number of mosquitoes and also absorb many infectious bites (Smith et al., 2007). Bed nets had been owned by each of the households in the present study, but most of them did not use bed net daily. The use of bed nets was found associated with the malaria prevalence among the participants. The households who used bed nets mostly, but not daily were most affected by malaria as compared to those who used bed net every night. Further malaria was found to be more prevalent among those who used LLINs as compared to those who used ITNs. Many studies have concluded that the insecticide treated bed net coverage was related to malaria control knowledge and significantly reduced malaria (Ahmed et al., 2011; Bhatt et al., 2012; Lowassa et al., 2012; Mulligan et al., 2008; Prakash et al., 2008).

Although the LLINs have been recommended widely as they remain effective for
several years, yet the ITNs have also been proved effective in reducing all cause malaria mortality and morbidity (Hassan et al., 2008; Mulligan et al., 2008). ITNs are easy to use and require less capital outlay as compared to the LLINs, which might lead to widespread use of ITNs on a large scale. The insecticide treated nets have also been shown to provide substantial protection against malaria, however sustainable use of ITNs need regular insecticide re-treatment considering the fact that they loose efficacy after some time (Hanson et al., 2009).

Association of malaria prevalence with environmental factors has been found in different endemic areas worldwide (Hightower et al., 2012; Kumar et al., 2014; Nath et al., 2012; Reid et al., 2012). It was observed that a moderately elevated area might have malaria vectors breeding locations in the surrounding low elevation areas. A study by (Haque et al., 2012) has shown that age and ethnicity of people, household density, proximity to forest and elevation were found to be positively associated with the malaria risk. Furthermore, a recent study in north-eastern part of India has also suggested that the forest cover was associated with the malaria incidences (Nath et al., 2012). The change in the forest cover may lead to change in the malaria vector composition and could play a significant role in overall malaria prevalence. Socio-economic status of the people has been found to determine the malaria prevalence in many investigations (Dhiman, 2009; Kumar et al., 2014; Nath et al., 2012). Researchers have shown that the economic condition of the people was negatively associated with the malaria parasitaemia (de Castro et al., 2012; Gosoniu et al., 2012).

Even if the malaria distribution is mostly determined by the climatic and environmental factors which affect mosquito and malaria parasite reproduction and proliferation at a given time, malaria is also influenced by various socio-economic
factors (Dhiman, 2009; Nath et al., 2012). In the current study, important associations among malaria prevalence history and various risk factors were observed which cannot be explained by any of the single factor included in this analysis. Although many factors were associated with the malaria prevalence, but none of the factor singly could be targeted for comprehensive malaria control. Malaria prevalence is a complex interplay of various factors, which may be region specific and most of which are inter-dependent upon each other. A better understanding of the association between malaria and associated factors is inevitable to design effective policies to tackle malaria. The present study of predicting socio-economic risk factors associated with malaria occurrence is first of its kind in the region and document that there are certain key factors which need to be taken care while allocating funds for addressing malaria problem in the region. Additionally extensive awareness among the people regarding malaria vectors and diseases, proper disposal of waste material, cleaning of mosquito breeding locations, use of personal protection measures and education about available health facilities are urgently required to reduce the malaria incidences in malaria hotspot areas.
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