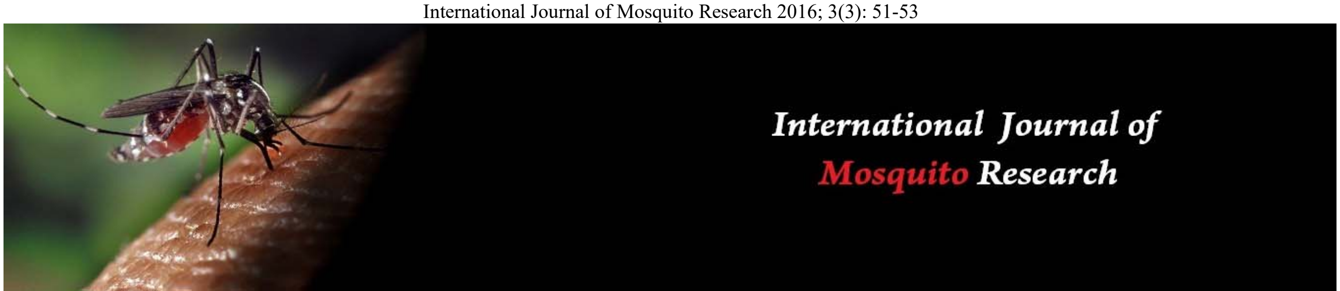

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Assessment of malaria high risk areas by using RS & GIS technologies in Rohtak and Mewat districts of Haryana

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Abstract
The presence of mosquito vectors *Anopheles culicifacies* and *Anopheles stephensi* in high numbers together with other malaria causing factors like poor drainage system, lack of knowledge about malaria, low socio-economic conditions etc has made malaria a major health burden in Rohtak and Mewat districts of Haryana. The primary objective of the study was to prepare thematic maps of six selected villages of Rohtak and Mewat districts for the year 2008 and 2013 by using RS & GIS technology. High Annual Parasite Incidence (API) of the village Kalanaur (3.48) in Rohtak district and village Ujina (5.1) of Mewat district was directly correlated to the number of water bodies with indication of favourable conditions for the breeding of anopheline mosquitoes in the respective villages. Hence, the present study identifies the risk factors associated with high malaria transmission in six selected PHCs of Rohtak and Mewat districts of Haryana and help to plan focused malaria control interventions to combat malaria transmission.

Keywords: Malaria, *Anopheles*, RS, GIS, thematic maps

1. Introduction
Malaria is one of the well-known oldest chronic diseases which have been proved to be a formidable deterrent to the cultural and socio-economic progress of human population in tropical, subtropical and monsoon prone zones of the world. It is one of the major public health problems in developing countries. According to World Malaria Report 2013 (WHO), around 207 million cases have been reported annually due to malaria, with estimated 627000 deaths [1]. However, for the last ten years no deaths were reported in Haryana due to malaria but there was a major outbreak in 1996 in Mewat district, with an estimated 1300 deaths. The factors responsible for this outbreak were believed to be the growing insecticide resistance (mainly DDT) among the mosquito vectors, poor drainage system, socio-economic factors, inadequate transport and communication, poor surveillance and monitoring mechanism [2].
As, RS (Remote sensing) and GIS (Geographical Information System) offer good opportunities to collect information about various environmental factors like landuse/landcover changes, vegetation and water bodies and vector abundance to built maps for assessing the high risk areas so that timely management of the diseases could be made possible at right time and in right direction. Hence, the present study was designed to prepare thematic maps of six selected villages of Mewat and Rohtak district by using RS and GIS technology, which may help to locate the presence of water bodies, built-up area and agriculture landuse as well as to validate the appropriateness of this technology in disease mapping and then correlate it with the API (Annual Parasite Incidence) of all the selected PHCs.

2. Material and Methods
2.1 Study Area
According to 2011 Census, Mewat district of Haryana which is situated between 26° and 30° North latitude and 76° and 78° East longitude adjacent to Gurgaon has a total population of 1089263 with an average annual rainfall of 336-440 mm [3] while Rohtak district falls under 28.89° North latitude and 76.57° East longitude with a total population of 1058683 and an average annual rainfall of 458 mm [4]. Apart from this, Mewat district has uneven topography of plain and undulating patches of land dotted with hillocks sandwiched between two parallel ranges of Aravali hills which runs along NS to NNE-SSW direction and are 5–10 km apart from each other.

Extreme climatic conditions prevail in Mewat, as it falls under sub-tropical, semi-arid climatic zone.
The literacy rate in Mewat district is 54.08% [5] while in Rohtak district it is 80.22% [6]. Both districts have rainy season from July to September which coincides with the peak time for malaria transmission, as high temperature and humidity during this period provides favourable conditions for mosquito breeding. Year-wise malaria incidence (2008-2012) which includes annual parasite incidence (API), total number of cases and population of six selected villages of Rohtak and Mewat district was collected from District Malaria Offices of respective districts.

2.2 Thematic maps

In the present study, satellite images of all six selected villages of Mewat and Rohtak district for the year 2008 and 2013 were obtained from Google earth. Thematic maps of selected villages were prepared showing landscape features like water-bodies, built-up area and agriculture land.

3. Results and Discussion

Thematic maps of landscape features like water-bodies, built-up area and agriculture land of six selected villages of Rohtak and Mewat districts were developed for the year 2008 and 2013.The total number of water bodies observed in Meham village of Rohtak district were expressed as M1 to M10, while in Kalanaur village these were expressed as K1 to K10, with no change in number from 2008 to 2013. But, in Bhaulat village the number of water bodies was increased from B8to B10 during the year 2013 as compared to 2008. It has been observed that sited M3, M6 and M10 in Meham, K1, K6 and K7 in Kalanaur, B3, B6 and B7 in Bhaulat village of Rohtak district were the most favourable sites for the anopheline breeding and hence responsible for the malaria transmission in the surrounding residential areas.
Further, the total number of water bodies in Ujina village of Mewat district was expressed as U1 to U9, while in Pinangwan village these were expressed as P1 and P2 with no change in number of water bodies from 2008 to 2013. In Nagina village, the number of water bodies had increased from four in 2008 to six in 2013 which were expressed as N1 to N6.It has been observed that sites U6 and U9 in Ujina village, P1 in Pinangwan village and N1 and N4 in Nagina village of Mewat district were the most favourable sites for the anopheline breeding. Also, in Pinangwan village the residential area surrounding the water body P1 was considerably increased from 2008 to 2013, leading to the increased number of malaria cases in the area.
As per epidemiological records obtained from district malaria office, Rohtak from 2008-2013, it was observed that the Kalanaur PHC has the highest malaria incidence (Average API= 3.48) followed by Meham PHC (Average API=2.27) and Bhalaut PHC (Average API= 1.8) which was directly correlated to the number of water bodies having favourable breeding conditions for anopheline larvae and also to the increased built-up residential areas around these water-bodies. Similarly, in Mewat district, Ujina PHC has the high malaria transmission with average API equal to 5.1 as compared to Pinangwan PHC with average API equal to 0.6 followed by Nagina PHC with Average API of 0.2 which was also correlated with number of water bodies and increased built-up area. It was also found that Pv cases were more prevalent than Pf cases in all the six selected villages of Rohtak and Mewat district. Beside this major malaria vectors reported in all study areas were *Anopheles culicifacies* and *Anopheles stephensi.*
In earlier studies conducted in India, GIS was used to identify malaria hot spots in districts/blocks of Madhya Pradesh, sub centres of Udalguri district of Assam and in 328 sub centres of 14 primary health centres (PHCs) of Ranchi district, Jharkhand, India [7-9]. Hence, RS and GIS based technology has been used to harness for case mapping and monitoring of vector control coverage by creating four types of region with different implications for disease control: high incidence and high risk, high incidence and low risk, low incidence and high risk, and low incidence and low risk.

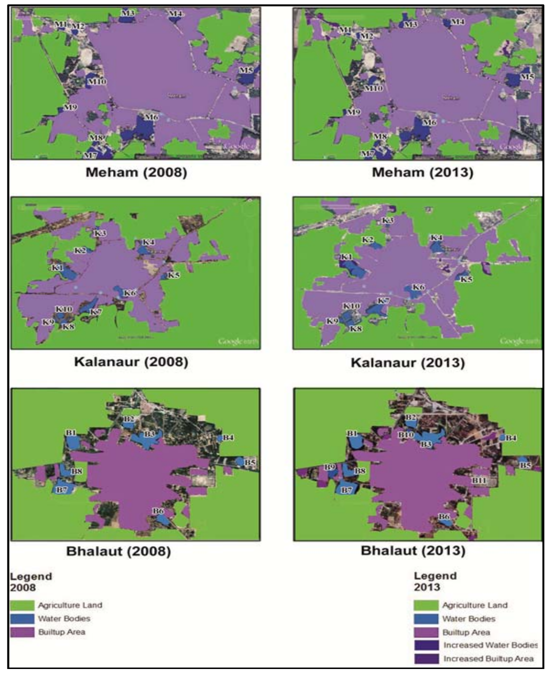

Fig 1: Thematic maps of Landscape Features of Selected Villages of Rohtak District.

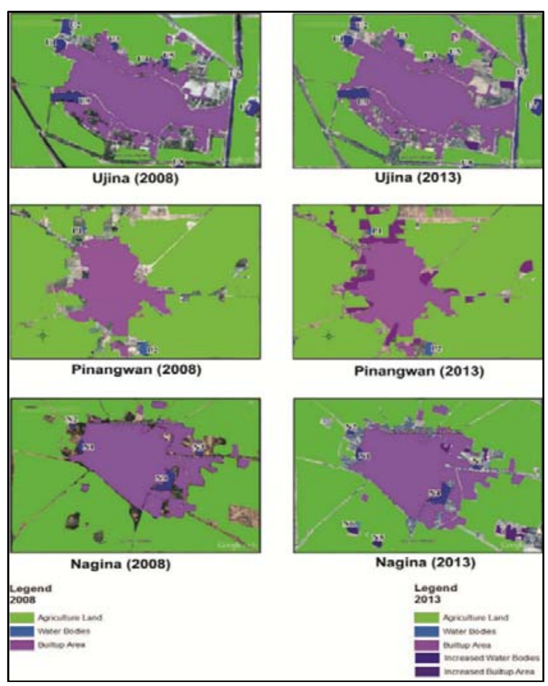

Fig 2: Thematic maps of Landscape Features of Selected Villages of Mewat District.

4. Conclusion
Earlier studies using RS and GIS based tools have been conducted in different parts of the country and have created new dimensions to the understanding, prediction, analysis and dissemination of spatial relations between disease, time and space which in turn will be beneficial in identifying high risk areas leading to effective deployment of interventions and optimal utilization of resources [10-16]. Hence, in the present study the use of this approach in six selected villages of Rohtak and Mewat district has enabled detection of high risk areas to ensure effective monitoring and proper utilization of malaria control interventions and thus facilitating decision making and policy formulation for enhanced malaria control.

5. Acknowledgment
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