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Preparation of Social Vulnerability Index of Malaria using MCDA technique in West Bengal, India

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Abstract :*Malaria is a vector borne disease, generally found in humid and high temperature induced areas. India is not exceptional for the spreading of malaria. Although, most of the cases are found in eastern and north eastern part of India. West Bengal has a consistent malaria incidence record since last decade. As, modern vector control equipment and medicines made the situation near to good, but some concentration of incidence are still active on some points of west Bengal. Here the study, not only identifies the zone active for malaria incidence, but also seeks the underlying social reason that made the incidence pattern more viable to some specific area. With the help of PCA, some social variables are taken and used to show incidence pattern from the viewpoint of three basic vulnerability sub-indices, susceptibility, resilience and adaptive capacity. Then composite scores also have been taken for consideration. At last, indices output has been validated under the circumstances of death causing malaria case.*

Keywords *–malaria in west Bengal, social vulnerability index of malaria, malaria*

I. INTRODUCTION

Malaria is a mosquito borne conveyable disease, that affects humans as well as animals through biting of female anopheles' mosquitos as a form of plasmodium type protozoa. Among various type of Malaria parasites, P. Falciparum is found to be most deadly compare to other like, P.Vivax, P.Ovale and P.malariae as they are to be the milder form of malaria. Plasmodium are mainly moves to Liver through blood and after getting maturity these protozoa attacks the body. Generally, with high fever, vomiting, headache and feeling tired are the most common clinical symptom. On the basis of severity, it could be eventually found as of yellow skin, coma and death. Among children, malaria could come with severity as a form of clinical symptoms as, respiratory problem, anemia and acute metabolic acidosis. Immediate medical response is needed after proper clinical diagnosis.

As in 2015, more than 90 countries have been affected of Malaria, but most astonishingly, according to WHO report, nearly half of the world population are at risk of malaria. Generally tropical and subtropical belt are most prone to malaria, as the local climate aggravates the potentiality of favorable mosquito breeding center, that makes this area more vulnerable to malaria. Most of the malaria cases happened in sub-Saharan Africa, though South-East Asia, Latin America and Middle East are also having some risk of malaria (WHO). According to WHO estimates, 212 million people affected of malaria in 2015 and among them 429000 deaths has been recorded. Sub-Saharan Africa are potentially occupying 90% share of total malaria cases and 92% deaths due to Malaria.

In India, malaria has spread a long ago, made the people to suffer from this deadly disease. During nineteenth and twentieth century, almost one fourth people have the risk of malaria, at that time, Punjab and West Bengal were the most malaria populated areas. Later, at the time of independence, 75 million decreased down 2 million in 1958 and further down to almost 50000 in 1961. (Lal et. al, 2000, Neena et.al, 2007, Dash et. al, 2008, NVBDCP published materials). The states of Orissa, Chhattisgarh, Bihar, West Bengal are predominantly distributed of malaria cases, though, other states have medium to low number of malaria cases (Sharma, 1996). According to NVBDCP report, Annual Parasite Index(API) of most of the states less than 2, where in Rajasthan, Goa, Madhya Pradesh and North eastern states has more than 2 up to 5. Most of the indo-gangetic plains and hilly regions have vivax cases than the other states of India (Dash, 2007).

After independence, Govt. started Malaria Control Programme in 1953 with successful implementation, after certain time, the policy got into problem due to technical and infrastructural execution deficiencies. But later, after 1960, with inception of Urban Malaria Scheme (UMS) in 1971-72 and Modified Plan of Operation(MPO) it regained its pace with successful execution of those policies in urban as well as rural areas. Generally, in India Malaria prevention works with spraying of DDTs, using Insecticide treated Nets, making mosquito breed ground close etc.

II. STUDY AREA

West Bengal eastern one of the important state of India. From the physiographic perspective, this state occupies hilly region as well as coastal, deltaic islands, laterite tract areas. The area of the state is 88752 sq. Km. This state is surrounded by Bhutan and Nepal in northern side, Bangladesh in eastern, western, Odisha, Jharkhand, Bihar and Bay of Bengal in south. It has 19 districts though four districts have increased in recent time. West Bengal have the location of

Formerly Calcutta (Now, Kolkata) City that are considered as largest city in eastern India. Major rivers of west Bengal are Ganga and Teesta and Bramhaputra.
Due to different physiographic to climatic and adaptation process to socio-economical parameters, the state has a unique character in each and every segment of livelihood process are found.
As India, is a part of sub-tropical climate zone, and especially eastern India has a distinct character with high temperature and high to moderate humidity which makes the area home ground of mosquito breeding zone. According to report, in 2006, Jalpaiguri, Puruliya, West Medinipur and Kolkata have some death recorded due to Malaria. Along with that, underdevelopment, and deprivation makes it worse for the people. But for the City like Kolkata have large number of malaria patient due to presence of high population density and low standard of living concentrated area. This malaria incident generally spread into some specific areas, with high population density and with substandard living.

III. METHODS

3.1 Conceptual Setting

Vulnerability means inability to withstand on the difficult and rigorous environment. Vulnerability is closely related with the phenomena that supposed to be a difficult time to withstand freely for mankind. Risk is also associated with vulnerability but differs with probability of likely to be happen of a certain incident. Vulnerability concept differs a lot, and literature review indicates towards a group of differential approach that tried to detect vulnerability from perspective using different type of indicators. According to Kienberger et. al 2009, Vulnerability means exposure, susceptibility and adaptive capacity. They used spatial Geons to depict out index parameters.

Social Vulnerability of Malaria has been defined and properly used by many researchers (Kienberger et. al 1994, Clutter, 1996) but most of the cases they implemented this index structure in national and sub-regional level. But for the case of small area like sub-regional level and district level it may not useful because non availability of satellite images. But direct use of statistical approach could be beneficial at that stage.

Vulnerability is very complex concept, that are very abstract in nature, direct measure is quite impossible. Using Multi Criteria Decision analysis, a series of available indicators compositely indicates the index number which depict out the result and vulnerable areas for malaria. Mono indicator process could not work out in that type of cases. At first, three broad categorization have been done and after that necessary proxies have been identified which could be quite useful for that analysis.

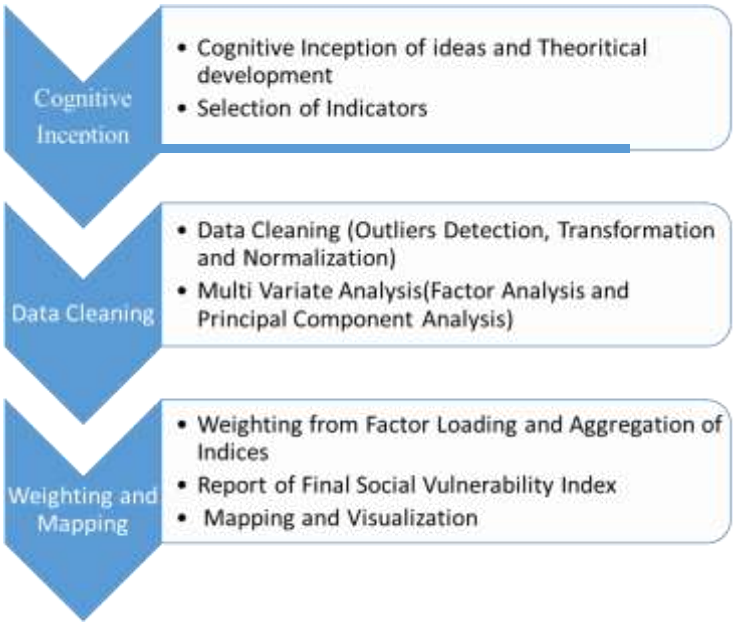


Figure 1 Flow Chart of Methodology

3.2 Composite Indicators

Epidemiological incidences are influenced by socio-economic factors, and that already been used by many researchers' like Bates et.al.(2004), Vincent(2004), and Bizimana (2015). Most of them used several proxies for their main indicators. After certain statistical cleaning, data has been used for indexing of malaria.

Variables/Proxy	Component(Factor Loading)				
	1	2	3	Weights	Scaled Weight
Factor 1:	Resilience				
Cemented floor materials	**0.964727**		0.113503	0.131	0.129575
Electrical Facility	**0.963155**		0.114677	0.132	0.130564
Having Television	**0.959126**		0.218312	0.137	0.135509
Having Mobile	**0.951696**		0.141444	0.131	0.129575
Modern energy used in cooking	**0.925653**		0.252947	0.135	0.133531
Having Radio	**0.904333**			0.123	0.121662
Having Banking Facilities	**0.891948**			0.112	0.110781
Having Water Closet Latrine	**0.820725**	-0.11075		0.11	0.108803
Total				**1.011**	1
Factor 2:	Susceptibility				
Population of children of 0-6 year	0.163246	**0.766528**	-0.42303	0.216	0.444444
Net Enrolment Ratio		**0.685093**	-0.50326	0.21	0.432099
Sex ratio	-0.2305	**0.638937**	0.480974	0.06	0.123457
Total				**0.486**	1
Factor 3:	Adaptive Capacity				
Literate Population	-0.29447	-0.73447	**0.36866**	0.042	0.06874
Immunization of Children		0.302901	**0.627895**	0.211	0.345336
Schedule Caste Population	0.204941	0.4967	**0.570359**	0.209	0.342062
Vaccination	-0.17014	0.257852	**0.413676**	0.149	0.243863
Total				**0.611**	1

Here Malaria vulnerability index has been used and it has been categorised into three sub ones, Susceptibility, Resilience and Adaptive Capacity (Kienberger, 2012). Here for the Malaria indices, several proxies have been used. The Resilience refers to the capacity to recovers quickly from difficulties caused by certain phenomena. House floor made of cemented materials are counted and then transferred into simple percentage of total household. Here housing floor is acted as proxy of living standard. Because, living standard influenced a lot to anopheles biting habit. Electrification percentage also used to find out of living standard. Users of TV, Mobile and Radio has been taken into consideration for the causes of exposure to the mass media. On emergency local civic bodies alert people from the ambiguous or explicit parasites or carrier through the recommendation of taking certain measures. Cooking materials and Latrine users are also acted as indicators of livelihood status of the people. Banking facilities also have an economic perspective and social necessity to get any sorts of subsidies from the Govt. This is very beneficial for the people.

Table 1 Factor Loading score taken from Factor analysis with PCA (Rotation:Varimax, Extraction: 3 factors, Low eigenvalues below 0.1 have been suppressed)

On the other hand, Susceptibility refers to the mankind are likely to be affected by certain phenomena. Here several proxies are presented to find out the susceptibility index, like the population of children having 0-6 years' age. This measures directly affects the vulnerability. Apart from that, Net Enrolment Ratio (NER) has been used. NER is an index related to education, first used by UNESCO to rationalize educational parameter among different nations worldwide. Here, NER of 19 districts has been taken into consideration. Eventually, sex ratio also used as proxy of susceptibility of malaria.

And eventually, Adaptive capacity is a sub indicator which would be the part of main indices. Adaptive capacity comprises of these three following proxy indicators like literacy rate of the districts. Here it should be noted that, although NER and Literacy percentage are both reflects educational parameters, but NER only counts of children enrolment ratio, on the other hand, literacy rate reflects overall adult population who have at least completed certain part of formal education. So, both are very different from its nature. Immunization percentage is also very important for the adaptation in such a surrounding where mosquito bites can cause a deadly Malaria. At the same time, Vaccination in 0-5 years' age can cause of a barrier from an infection. After all, an indirect proxy has been used. It is well established that, and confronted by WHO also that, in India, industrial belt, marginal hill region and informal squatter can cause Malaria

an epidemic. As schedule caste population are known to be underdeveloped and seems to be isolated in marginal areas could be a proxies of marginal people who are direct vulnerable to Malaria.

3.3 Procedure of composite index construction

At the beginning of construction of Indices, at first, theoretical base has been gained and then carefully indicators along with proxies (whenever direct indicators not available). Then data cleaning procedure has been taken place. In the data cleaning procedure, at first, outliers have been detected through the analysis of stem of leaf plot and box plot. Here, kurtosis value also has been taken into consideration. Total of 22 indicators has been taken for the analysis. Here fixing of outliers has been needed. But through winsorization procedure, data could be manipulated and the risk of wrong analysis could take place. So, outliers have not been fixed; though the data could not be fixed due to some abnormal high values found for Kolkata district.

After that normalization procedure has been taken place. Rather use of Z score, 0-1 normalization procedure has been applied. Because, using Z score, negative values could come and dealing with negative values could be confusing, so according to literature, 0-1 normalization procedure has been applied for individual indicators following the formula,

$$Vi = \frac{(Vi - Mini)}{(Maxi - Mini)}$$

After normalization, Multicollinearity has been tested through Corrplot() syntax in R platform. Then Factor analysis has been done with previously mentioned 22 variables of 19 districts. Factor analysis has been done with Principal Component Analysis technique and using Varimax rotation technique. At first, analysis has been done using more than 0.1 eigenvalues allowance. But through the scree plot and factor loading it shows 6 factors. As data are presumed with three factors, again factor anlysis process has been done with 3 factor predefined within the process. Then according to factor loading eigenvalues, factor score (unrotated) has been taken from the factor score matrix. Eventually, among 22 variables, only 15 variables have been taken for further analysis.

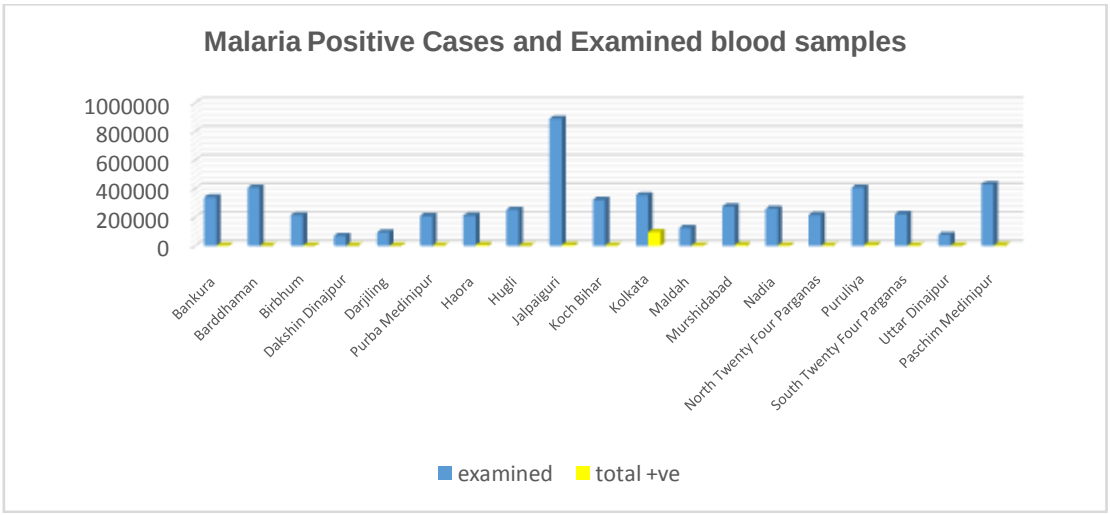
In every sub-indicator section, a semi- composite score has been depicted in three heads, Loss of resilience, susceptibility and adaptation capacity. Here as adjusted weight has been used so further division by the total indicator based weight has not been done. Then further these score has been added to find out Malaria Vulnerability Index.

IV. ANALYSIS

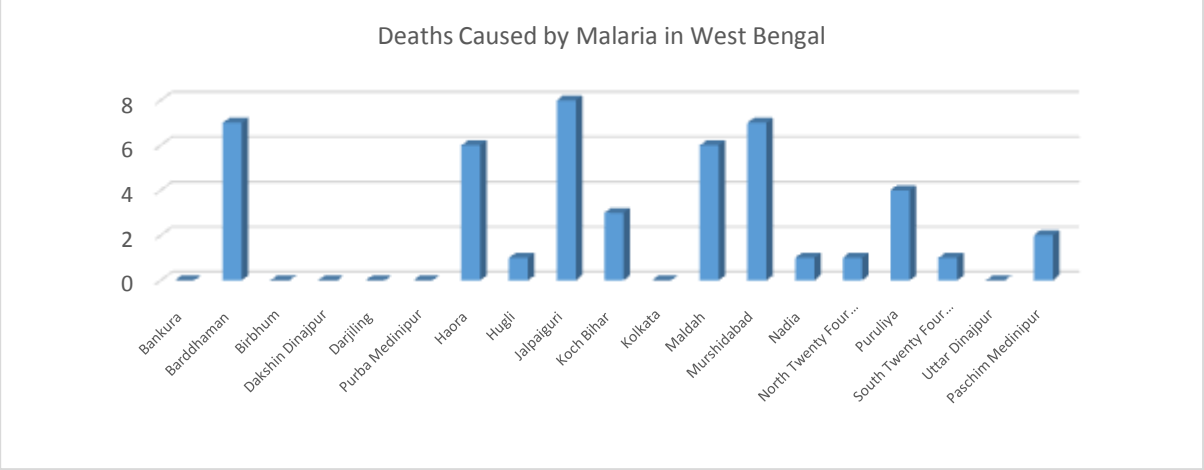
4.1 Basic Analysis

West Bengal is one of the most important state in eastern India. It has Bangladesh in east, Bihar, Orissa, Jharkhand in west and Nepal and Bhutan in North and Bay of Bengal in south. This state has a distinct characteristic in terms of spreading of vector borne disease. It has 19 districts, as another 4 has been declared, but due to shortage of data, it has been completed with 19 districts.

There are some distinct characteristics regarding malaria incidence. According to WHO, west Bengal is also in endemic zone of malaria. But technically malaria incidence could be reported as number of blood sample collected and as of positive cases has found. From the visualization,

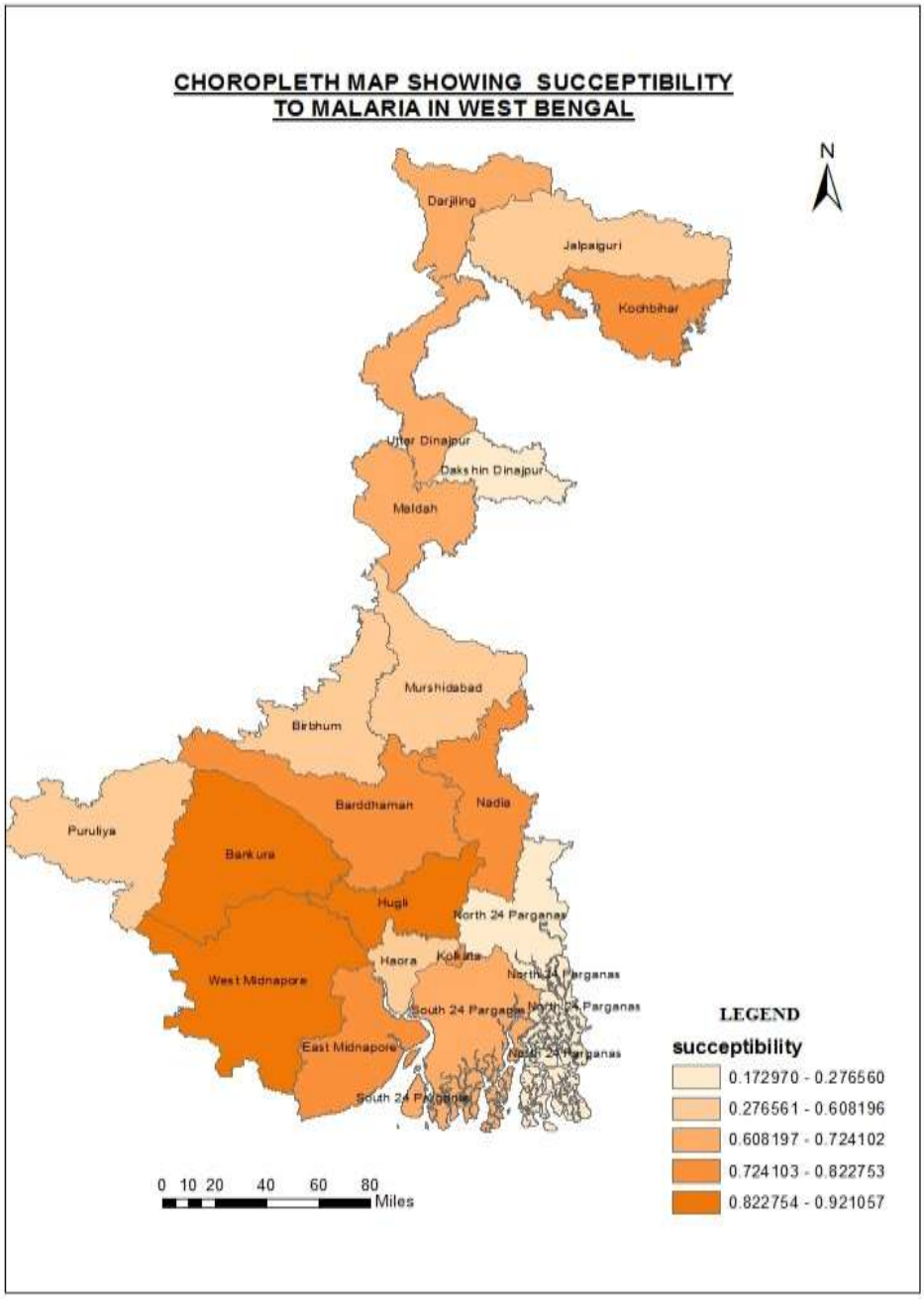


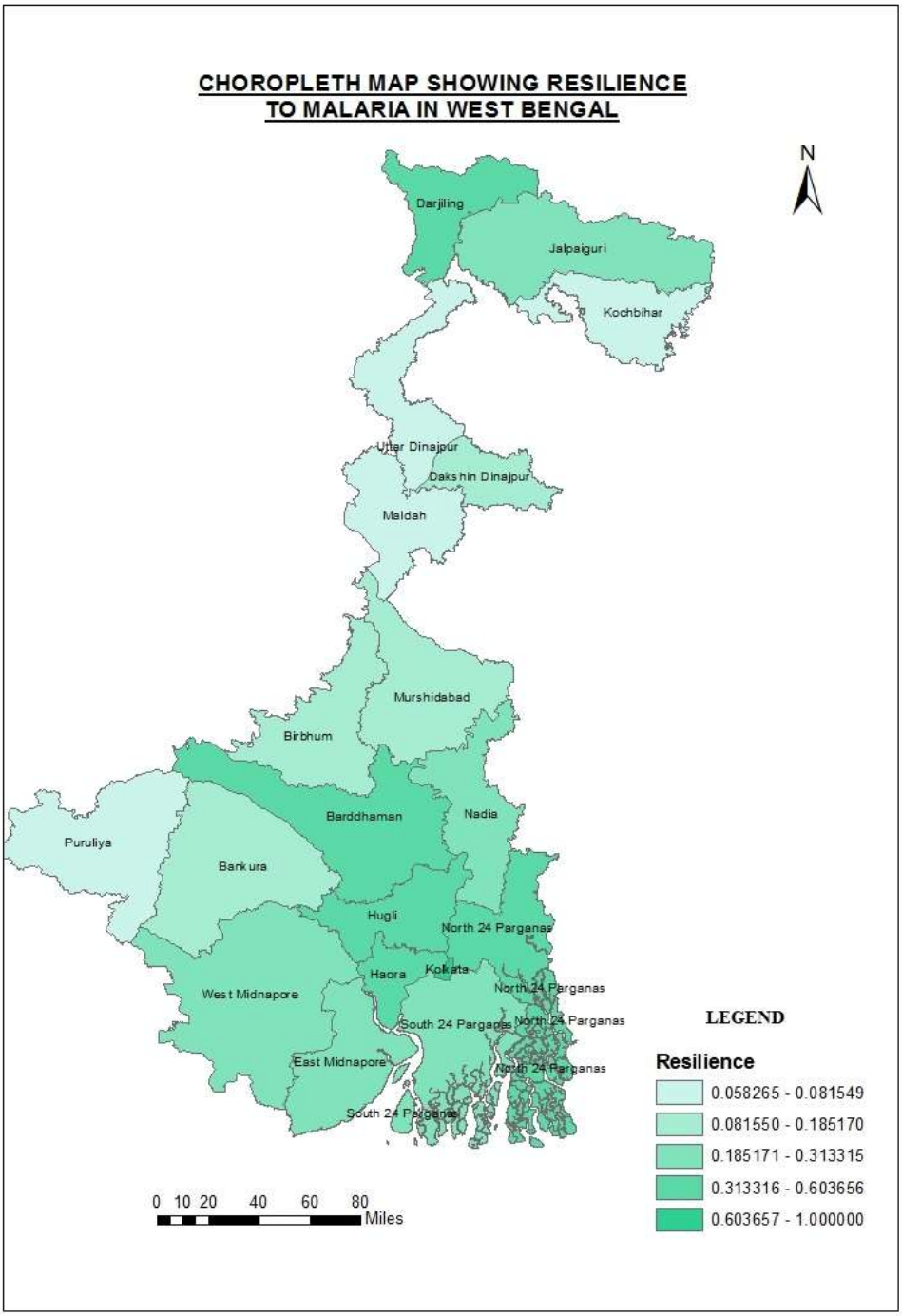
It is very clear that, as Jalpaiguri district has very high rate of examine blood cases, but the overall highest malaria cases found in Kolkata due to very high population density with substandard living. The other state has very nominal number of malaria cases. But the picture is just opposite if it can be shown the death caused by malaria in west Bengal. Because in spite of the number of malaria cases are high in number at Kolkata, the death rate is much higher in other districts. Probably due to satisfactory health facilities are not provided and the standard of the facilities are not up to the mark in compare to Kolkata.

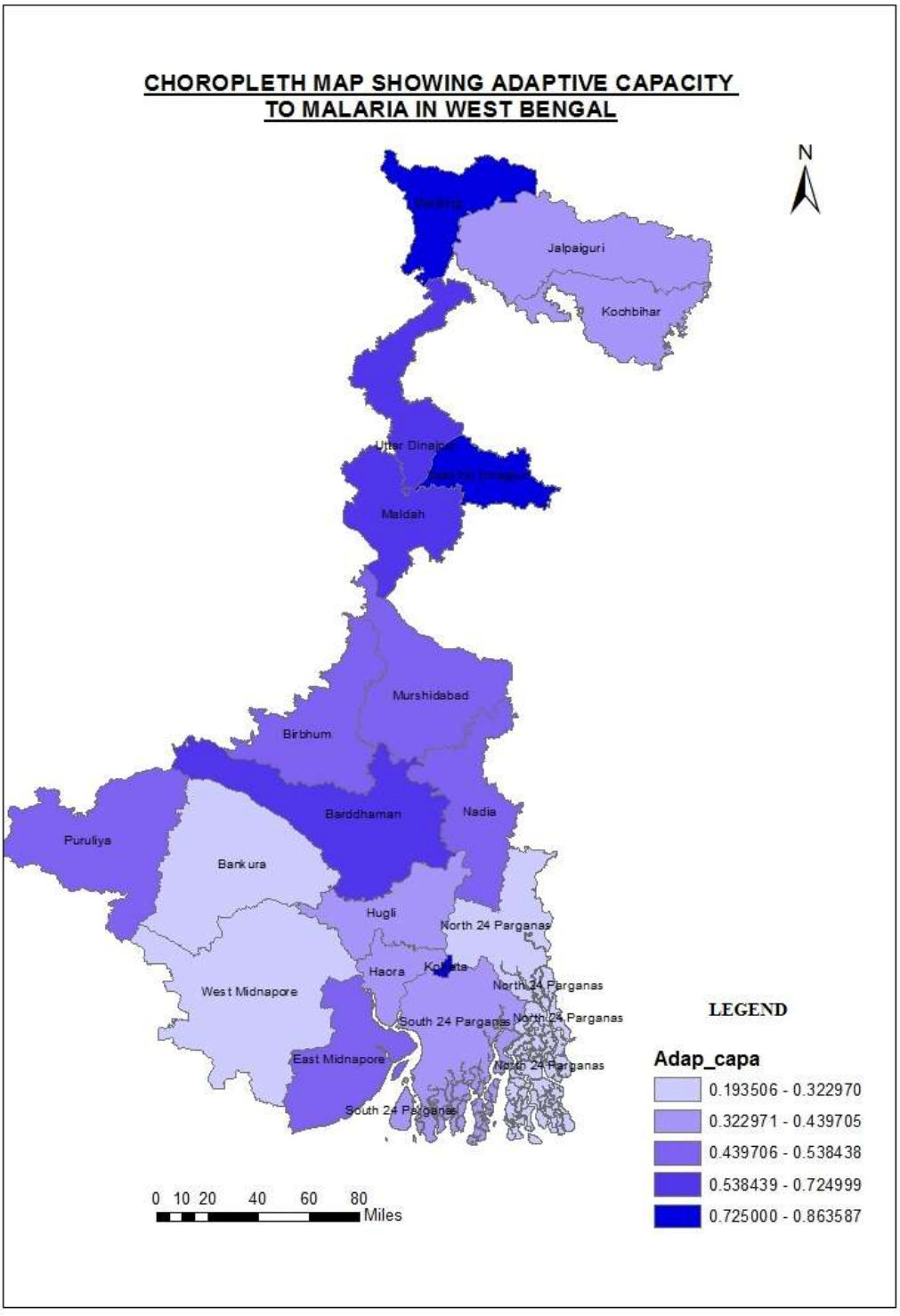


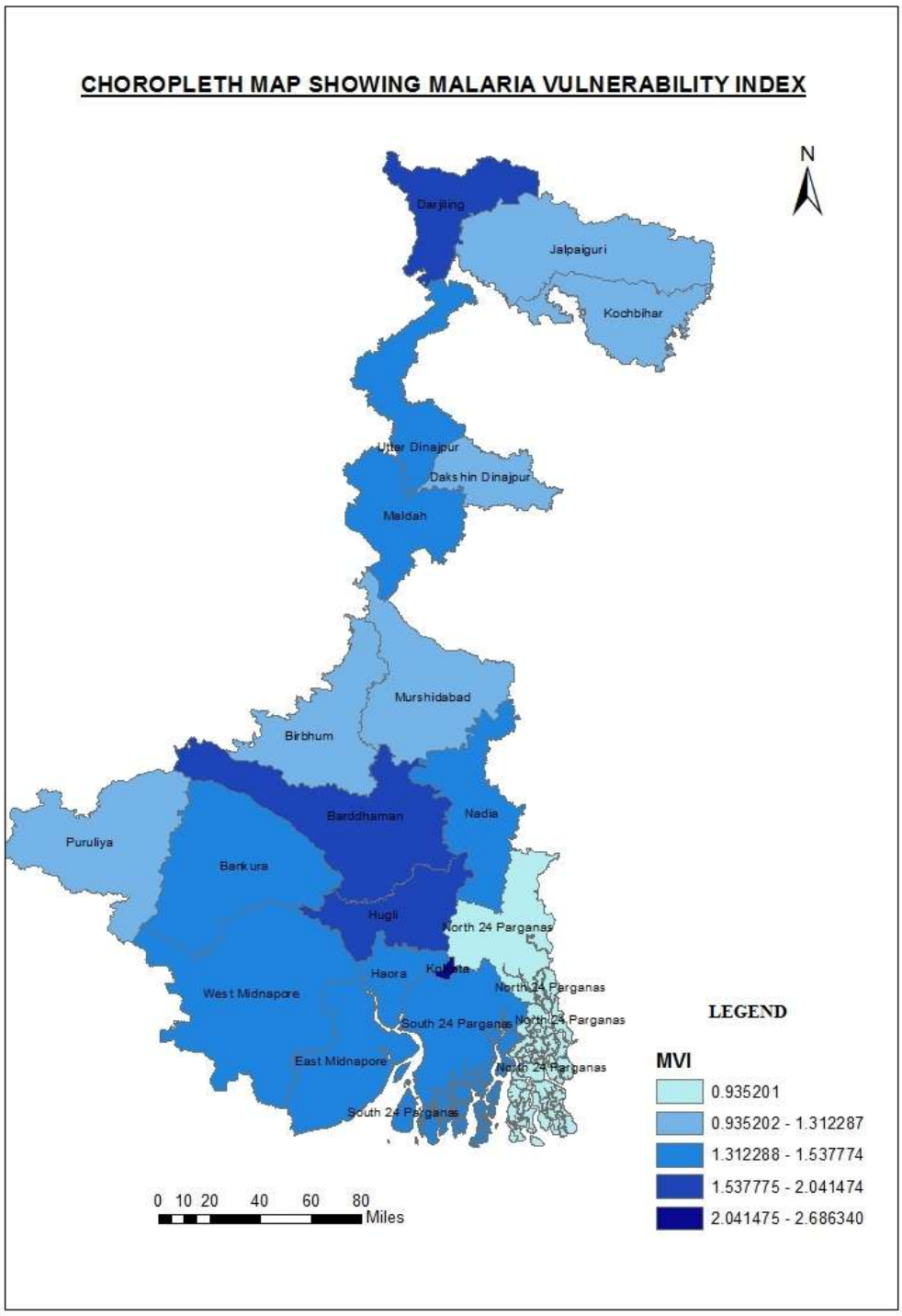
4.2 Malaria Vulnerability Index

Malaria vulnerability index has been prepared on the basis of three sub-indicator based indices which is resilience, susceptibility and adaptive capacity.









Malaria vulnerability index has been prepared on the basis of three basic parameters.The first parameter which is Susceptibility which made of 8 possible proxy variables. Generally this part of index is considered from the viewpoint of standard of living. As these variables can influence over vector borne disease. The factor susceptibility controls over the whole west Bengal, as most incidence induced state does not have high value, but it shows moderate to high value. For the case of resilience, Kolkata and surrounding districts score a more than the other districts and in northern portion, Darjeeling and Jalpaiguri district have moderate to high score. On the other hand, for susceptibility measures, Kolkata and surrounding states also have high score and Koochbihar have also have high score Darjeeling and Jalpaiguri have lower to moderate score to be seen. Eventually, for the last factor adaptive capacity, Only Kolkata and northern and middle districts score higher than the other districts. On the basis of three sub-indicator based indices which is resilience, susceptibility and adaptive capacity.

Malaria is a vector borne disease that not only depends on climatic factors, but also it has some dimension that have an influence on socio-economic parameters. From the Vulnerability Index, it is very clear that, Kolkata district have

possessed high value, and Bardhhaman, Hugli, Jalpaiguri, Paschim Medinipur have moderate value. Validation of the indices also have been examined. Comparative bar diagram has been shown here.

V. CONCLUSION

No model can fully predict the issues. From the composite score of indicators, it has been tried to predict the vulnerability score that can show the probability and risk factor of malaria. For the case of west Bengal, every probable indicator has been taken into consideration. But from the picture of malaria of 2010-12, it is very clear that, malaria is not only a disease that spread rapidly, but it is more a disease that effects on people who does not have the affordability to take the medical facilities on emergency.

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