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Disease control and combat mapping for tribal fortification using GIS –a case study for selected tribal blocks of Rayagada district, Odisha

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Abstract: Importance of health with respect to all living beings needs no special mention in the contemporary society. However, due to lack of awareness and health care services, many parts of our nation are still gravely affected due to several diseases, mostly the rural areas in general and much in particular the tribal villages. Most of the regions in India still have poor health protecting infrastructure facilities and as a result of which majority of the rural population is suffering from many diseases that could have been controlled with proper understanding of the disease causative process and possible preventive measures. In order to provide with better health care facilities in the Public Health Centres (PHCs), a data base of the disease causing agents and the remedial measures in the form of GIS maps will help in regularly monitoring the health level of rural public. An attempt has been made to map most common factors of prevalent diseases in rural and tribal regions in selected blocks spread over Rayagada district of south Odisha state and to develop a health care information system for the tribal regions. A well set methodology wherein the sum of the product of the weightage and rating considering various influencing parameters that result in an index referred as "Disease Vulnerability Index" (DVI) is evaluated for a number of villages in the selected blocks of the study area. Data analysis has been done for disease vulnerability mapping considering environmental factors, factors that are responsible for the sustenance of Disease Causing Vectors (DCVs) (Climatic factors), and factors that resist the growth of D.C.Vs (General Sanitation & Drainage). Each of the disease causing agents and disease spreading means has been assigned with a weightage factor indicative of the disease causing potential. Based on the relative levels of disease causing agents, each parameter has been assigned with a ranking on a 1 to 10 scale to assess the vulnerability level of the parameter at a certain location. Finally Disease Vulnerability Maps and Disease Control and Combat maps have been generated for each of the blocks under consideration using GIS layering. Number of villages with high % vulnerable values and low % vulnerability values for each block in the study area and number of villages with varying levels of disease controllability could be obtained.

Keywords: Disease Mapping, Disease vulnerability index, Geospatial Analysis, PHCs

1. Introduction

Importance of health with respect to all living beings needs no special mention in the contemporary society. Lack of awareness and availability of good health care services in tribal villages, in particular is a serious issue in India. In addition, illiteracy among tribal population, remoteness of the villages they live in, lack of clinical / pharmaceutical infrastructural services and the age old practices adopted for curing with reluctance for undergoing current day advanced treatment methods further aggravates the situation. As a result of all these factors, most of the tribal population in our country are falling a prey to several water borne and vector borne diseases(www.cips.org.in/documents/DownloadPDF/downloadpdf.php?id=66&category=Health).

Recent advances in GIS and Global Positioning System have created new opportunities for public health administrators to enhance planning, analysis and monitoring of vector born disease identification and elimination (https://nrhm-mis.nic.in/Orissa Health GIS_Mithun NRHM.pdf). However, the work related to geospatial health networking is in initial stages and has not spread over the width of the nation.

Most of the regions in India have still poor health protecting infrastructure facilities and as a result of which majority of the rural population is suffering from many diseases that could have been controlled with proper understanding of the disease causative process and the preventive measures (http://icmr.nic.in/annual/2014-15/RMRC_bhub.pdf). In order to provide with better health care facilities in the Public Health Centres (PHCs), a data base of the disease causing agents and the remedial measures in the form of GIS maps will help in regularly monitoring the health level of rural public. In the present context, an attempt has been made by a team of investigators belonging to Department of Civil Engineering, Centurion University of Technology and Management, supported by DST, Government of India, to generate maps that are indicative of disease vulnerability and possible control and combat of diseases in rural and tribal regions spread over two districts in South Odisha state (www.nrdms.gov.in, Project Report Submitted to DST: Project No.: NRDMS/01/41/014 (G, P-11) March 2018.). This paper deals with the analysis of the data collected w.r.t. selected blocks of Rayagada district of South Odisha. Five blocks of the district have predominant rural and tribal population. Preliminary study has observed that the general health conditions of these rural and tribal public are deteriorating due to the prevalence of certain diseases, which could have been prevented with a little understanding of the disease causing processes and the preventive steps. It has also been observed that there is no proper data base pertaining to these diseases in these regions.

2. Study area

The study area includes certain blocks of Rayagada district of the state of Odisha, India that lies between 19°0'00"N to 19°58'00"N latitude and 82°54'00"E to 84°02'00"E longitude. It covers a total geographical area of 7584.7 sq. km. As per 2001 census, total population of the district is 8,23,000 out of which 1,17,524 (14.28 %) are SC, 4,61,209 (56.04 %) are ST and 2,44,266 (29.68%) are OC. Density of population is 116 person/ sq. km. Literacy rate of the district is 35%. In the district of Rayagada more number of blocks have tribal population and it is a real requirement to provide health care services to all the tribal population of these blocks. The selected blocks are of B. Cuttack, Gudari, Munigada, Kashipur and K. Singpur since they happen to be the blocks with more tribal population in the district (Figure 1). The locations of PHCs and subcentres as mapped by NRHM, Government of India are also shown in figure 1. Hardly there is any study on the vulnerability of villages to major diseases along with information on the possible steps to be initiated to control the spread of diseases. In this context the proposed study is more or less first of its kind to collect data on the disease causing factors and those factors which will enable to assess the possibility of control of the spreading of diseases.

3. Objectives

This study addresses various problems associated with spreading of diseases in tribal regions and provide proper health information for sharing among all the concerned agencies and organizations. Since GIS platform is most suitable for information sharing and applicability, it is considered in the present study to generate the disease vulnerability and control information in the form of GIS maps. The mapping technologies can create interactive interfaces for users, with the support of GIS basic functions such as zoom in, zoom out, pan, and hyperlink. Thus, a geospatial-enabled approach has been performed in this study for semantic health information retrieval with the following specific objectives:

- Identification of most prevalent diseases causing health impairment in the tribal population in the study area.
- To map pockets those are most vulnerable for the diseases and evaluate disease vulnerability index for the study area

To prepare disease vulnerability index map and control and combat map for the study area.

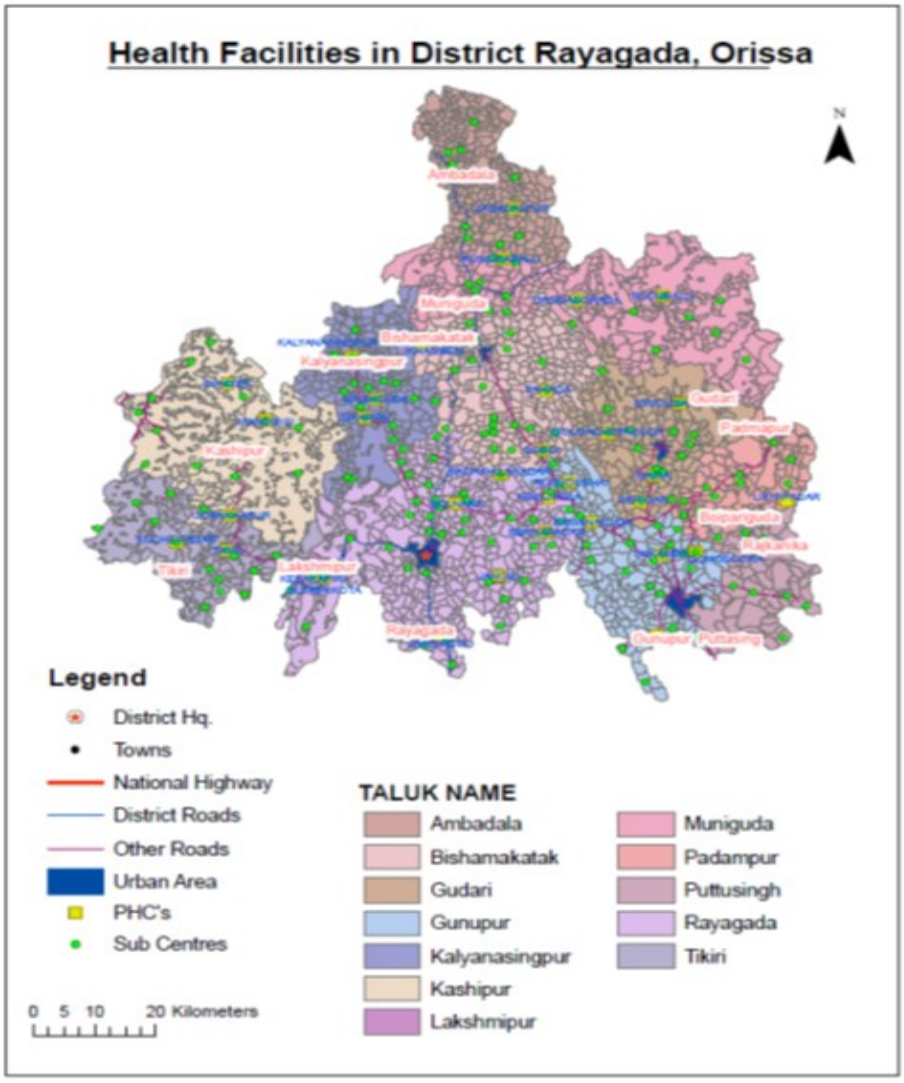

Figure 1: Study area map with locations of PHCs and subcentres

4. Methodology

The present study is a part of Geospatial Health Networking project of Department of Science & Technology (DST), Govt. of India, in which a sub-project on Disease Vulnerability and Disease Control mapping has been taken up. The study is based on availability of data related to rural health care services in the district and geographical accessibility of the health services. Important factors considered for baseline study and analysis are rural population, available health centres, roads, sanitary status, literacy, water bodies, drainage facilities etc. Preliminary discussions and interaction with district medical officers revealed that the most prevalent diseases in the selected tribal blocks are malaria, filariasis and anemia. Deliberations in a Workshop conducted with district medical officers and ground staff of PHCs and other related personnel concluded that the factors responsible for causing and sustenance of the identified diseases are more or less common. These can be categorized under three classes, viz., (i) Environmental factors, (ii) Climatic factors and (iii) General sanitation & drainage factors. Any one or combination of these factors would possibly be favourable to the growth of Disease Causing Vectors (DCVs). Awareness factors and preventive factors decide the possible extent of control the spread of diseases. Based on the nature of these factors each of them are assigned with a weightage in the scale of 1 to 10. Tables 1 and 2 given below indicate these Disease Vulnerability Factors (DVFs) and Disease Controlling Factors (DCFs) along with the assigned weightages. Subsequently, a questionnaire has been developed in consultation with district medical authorities for the identification of extent / level of impact of the disease causing factors as well as those factors that would possibly enable the control of the disease against its spreading, along with their relative level of impact. The questionnaire is developed in such a manner that it enables not only identifying the influencing parameters under the DVFs and DCFs but also their potential in assessing the vulnerability or control index. Each of the DVFs and DCFs are subdivided into several parameters that have high, medium and low weightage w.r.t. to disease vulnerability or control as the case may be. In tables 1 and 2 all the identified parameters have been listed along with their possible influence (high/ medium / low). Further, depending on the nature / level of each of the parameters in a particular village, a rating is fixed again in a 1 to 10 scale following the information gathered from the questionnaire (Table 3).

Table 1: Disease Vulnerability Factors (DVFs)

Nature of Factor	Parameters	Weightage@ (Numerical Value)	Remarks
Environmental Factors	Presence of Disease causing vectors	High (10)	More Vulnerable
	Water bodies	High (10)	Impact is more
	Toilets & Sanitation within the Dwellings	High (10)	Poor Sanitation worsens the situation
Factors responsible for sustenance of D.C.Vs (Climatic factors)	Rainfall	Low (1)	Normally less impact on sustenance of D.C.Vs
	Temperature	Medium (5)	Higher temperatures may favour the growth of D.C.Vs
	Humidity	Medium (5)	Higher humidity is many times favourable for the growth and sustenance of D.C.Vs
Factors that resist the growth of D.C.Vs (General Sanitation & Drainage)	General Sanitation in the Village	Medium (5)	Considered to have a medium influence in resisting the growth of D.C.Vs.
	Type of Dwellings	Low (1)	Normally the type of built houses will not have much influence on the D.C.V growth.
	Drainage & Roads	Medium (5)	Considered same effect as of general sanitation in the village.

Note: @The weightages are assigned by the project team as per their relative impact as indicated in the remarks column.

Table 2: Disease Control Factors (DCFs)

Nature of Factor	Parameters	Weightage@ (Numerical Value)	Remarks
Health Awareness Factors	General Literacy	Low (1)	Though literacy is important, the literacy level being normally low in the region, the level of literacy is considered to have a low impact.
	Health Awareness Programmes by Govt & Voluntary Organisations	Medium (5)	The health awareness camps & programmes though will educate the public its impact is considered towards motivation for better health care. Hence a medium impact is assigned.
	Vaccination programmes conducted	High (10)	If regular vaccination is carried out, it will have a high impact in controlling the spread of diseases.
	Availability of ASHA & ANGANWADI Workers	Medium (5)	Availability of the ASHA & Anganwadi workers will ensure continuous awareness creation and thus considered to have a medium impact on awareness creation.
	General Treatment & Religious Beliefs	Low (1)	Since the diseases of highly critical nature, the type of treatment and the religious practices will have a low impact.
Preventive Factors	Symptoms Identified & Reported	High (10)	Early identification and reporting of cases will have high influence in preventing the spread of the disease.
	Location of PHC	Medium (5)	Although the proximity of PHCs will control the spread of the disease, the general facilities within rural health centres will not improve the situation of controlling the disease and hence a medium weightage assigned.
	Availability of 108 Services	High (10)	Ready availability of 108 services will enable quick ontrol on the spread of the disease.
	Accessibility of Medical Practitioners	Medium (5)	Effect same as that w.r.t the PHC location.
	Availability of Qualified Pharmacist	Low (1)	General availability of qualified pharmacist in tribal villages is far from reality and hence this parameter will not have significant influence on controlling the disease.
	Road Connectivity with Headquarters	Medium (5)	Better road connectivity will provide a better chance to control the spread of the disease and hence a medium weightage is assigned.
Note: @The weightages are assigned by the project team as per their relative impact as indicated in the remarks column.			

Table 3: Parameter rating

S. No.	Category of parameter	Rating Assigned				Remarks
		(a)	(b)	(c)	(d)	
1	PHC Location	1	4	8	10	If present within village less vulnerable
2	Medical shop location	1	4	8	10	
3	Availability of Registered. Medical Practitioner	1	4	8	10	
4	Surface drainage system	1	4	8	10	Presence of canals provide better drainage
5	Habitat type	10	4	8	1	Presence of RCC habitats better clean climate
6	Sanitation in village	1	4	8	10	Better sanitation better control
7	Toilet facilities in village	1	4	8	10	Better type of toilets (with septic tanks) better control
8	Road facilities	1	4	8	10	Black top & RCC roads provide better control
9	Existence of schools	8	4	1	10	Higher educational facility better awareness
10	Anganwadis / Health care units	1	4	8	10	Proper organization better awareness
11	NGOs operating	1	4	8	10	If covered by NGOs better awareness

12	Vaccination Programmes	1	4	8	10	Regular vaccination better control
13	Health awareness camps by Govt. and NGOs.	10	8	4	1	More frequent camps better control & awareness
14	108 services	4	8	10	1	Availability in close proximity control spread
15	Types of treatment (Religious based)	10	8	4	1	Treatment based on religious beliefs lead to more ignorance and more vulnerability

The sum of the product of the weightage and rating result in an index which is referred here as "Disease Vulnerability Index" (DVI). A similar index is arrived by using the disease controlling parameter and the same is termed as "Disease Control Index (DCI)".

$$DVI = \sum_{i=1}^{n} [P_W]_i \mathrm{x} [P_R]_i \quad \text{- - (Eq. 1)}$$

where $[P_W]_i$ = Weightage assigned to i^{th} influencing parameter,
$[P_R]_i$= Rating of the i^{th} influencing parameter in a particular village and
n = total number of parameters.

The magnitude of DVI will reflect the relative vulnerability at a village. The values of DVI have been mapped for the selected block in the study area. The map thus generated is known as the disease vulnerability index map. Similarly, Disease Control and Combat Index has been arrived considering disease controlling parameters. The methodology is schematically shown in the flow chart (figure 2). As a part of the data collection for index evaluation and integrated map generation, data is gathered from several villages through the questionnaire.

5. Results

Information obtained from the questionnaire is converted in to numeric data required for assessing the ratings of each of the parameters identified under DVFs and DCFs. A ratings matrix for each of the factors is generated for different locations in the study area using the assigned ratings as per table 3. All the spatial data of the product of ratings and weightages are integrated into GIS environment for storage, retrieval, manipulation, analysis and generation of a composite map that is indicative of the disease vulnerability of the block as a whole.

General disease vulnerability maps have been derived separately for 5 Blocks of the Rayagada district using the computed values of DVI. Disease control and combat maps are also generated for these blocks. Figures 3a to 3e show the disease vulnerability maps for the blocks of K. Singhpur, B. Cuttack, Gudari, Kashipur and Muniguda generated through GIS technique. Similarly figures 4a to 4e show the disease controllability maps for the above mentioned blocks. Table 4 shows the number of vilages with percentages of high and low vulnerability in the above mentioned blocks in the Rayagada district. The information with regard to the disease controllability in the selected districts is presented in table 5. The outcome of the study creates necessary information bank for assessing the vulnerability of a location for general diseases and the possibility of its control with existing infrastructure and the environment.

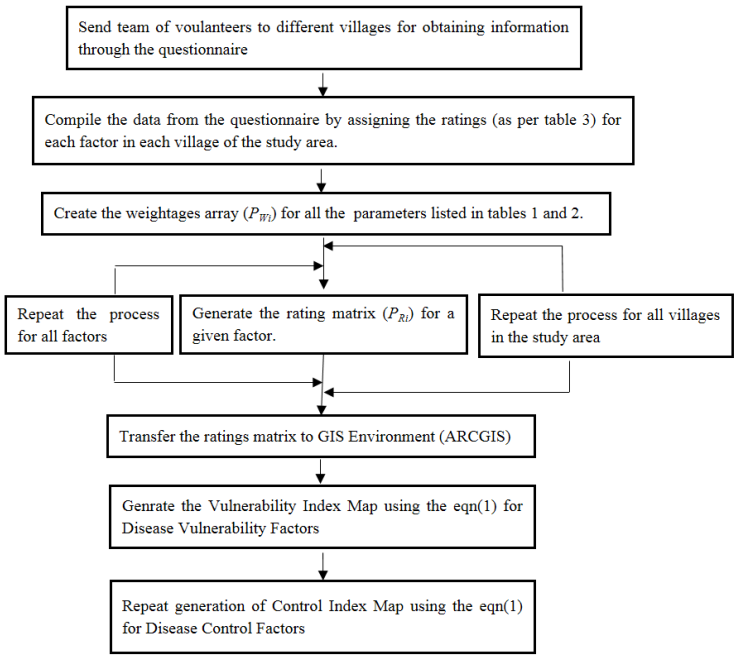

Figure 2: Flow chart

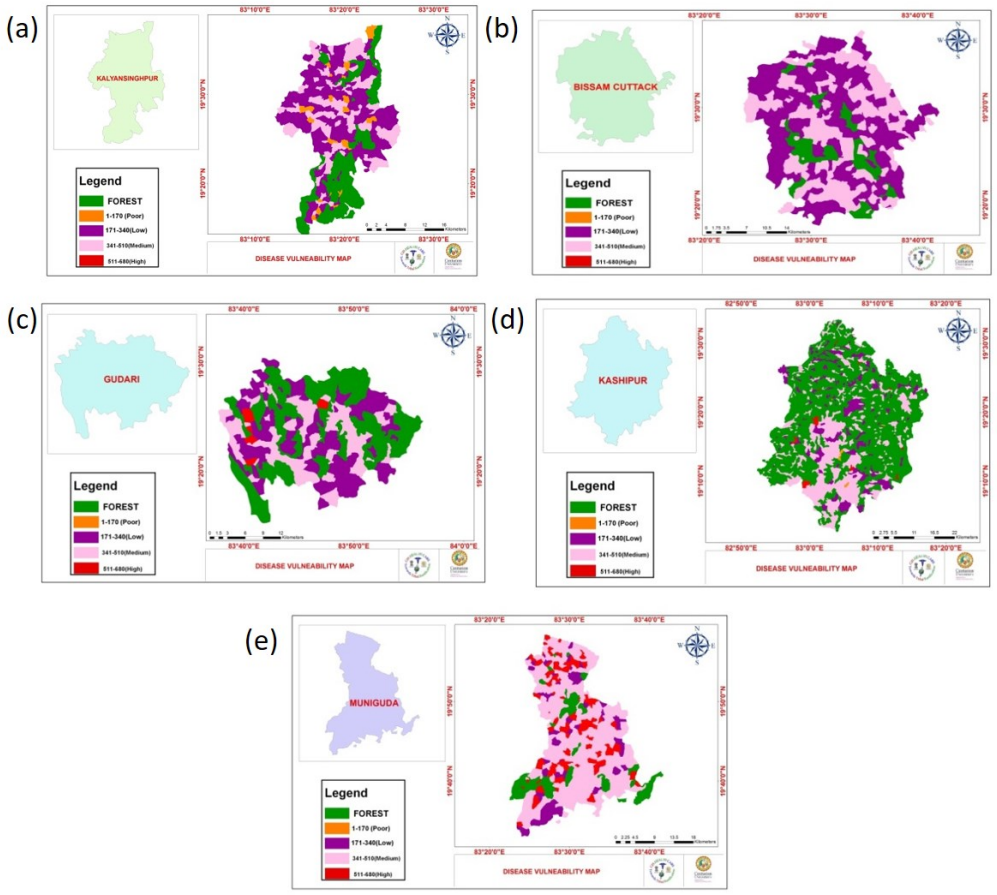

Figure 3: (a) DVI Maps for K. Singhpur Block, (b) B Cuttack Block, (c) Gudari Block, (d) Kashipur Block and (e) Muniguda Block

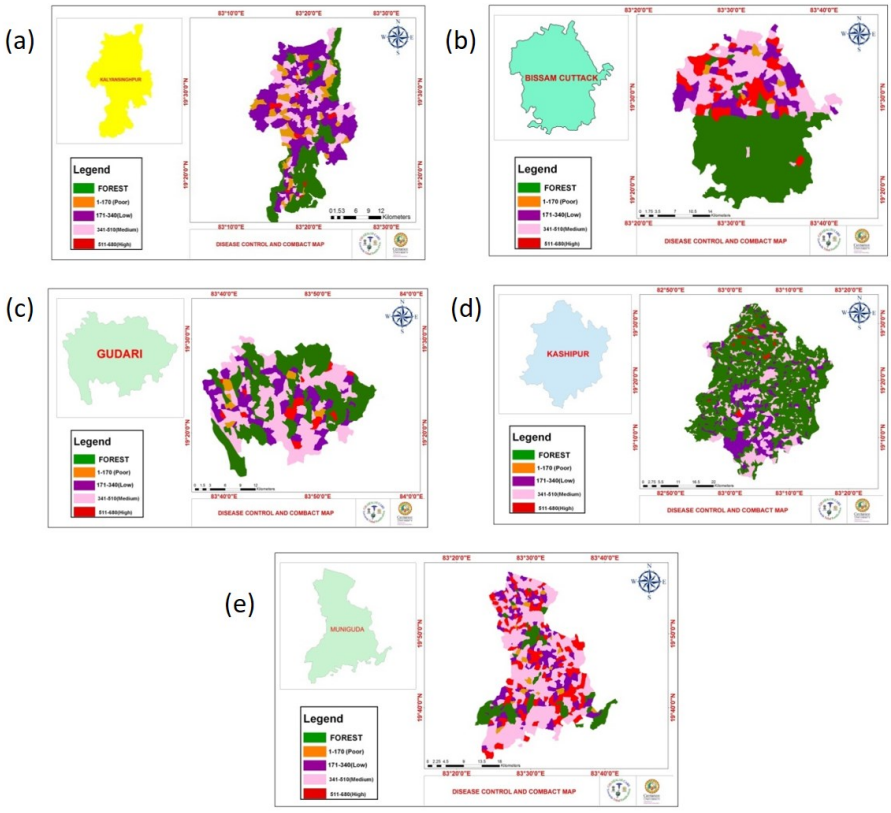

Figure 4: (a) DCI Maps for K. Singhpur Block, (b) B Cuttack Block, (c) Gudari Block, (d) Kashipur Block and (e) Muniguda Block

Table 4: Vulnerability information for selected blocks in Rayagda District

Block	Total no. of villages in the block	Villages High Vulnerability (DVI 511 - 600)		Villages with Least Vulnerability (DVI <170)	
		No	% In the Block	No	% In the Block
B. Cuttack	282	26	9.00	132	47.00
K.Singpur	223	29	13.00	132	59.00
Kashipur	406	45	11.00	201	50.00
Muniguda	366	43	12.00	198	54.00
Gudari	152	13	9.00	78	51.00

Table 5: Vulnerability Information for Selected Blocks in Rayagda District

Block	Total No of Villages in the Block	Villages High Control (Index: 511 - 600)		Villages with Control (Index: 341 - 510)		Villages with Less Control (Index: 170 - 340)		Villages with Least Control (Index: < 170)	
		No	% in the Block	No	% in the Block	No	% in the Block	No	% in the Block
B. Cuttack	282	65	23.05	103	36.52	105	37.23	9	3
K.Singpur	223	32	14.35	83	37.22	99	44.39	8	4
Kashipur	406	60	14.78	72	17.73	261	64.29	8	2
Muniguda	366	56	15.30	88	24.04	208	56.83	8	2
Gudari	152	14	9.21	43	28.29	82	53.95	14	9

7. Conclusions

The study enabled identification of several factors that are significant in disease spreading as well as its control. The parameters have been identified as Disease Vulnerability Factors and Disease Controlling Factors. These factors include different parameters with varying potential w.r.t disease spreading or control. Two indices are computed for each of the village in the selected blocks of the study area based on weight rating product summation methodology using parameters collected from field in form of a questionnaire. Disease Vulnerability maps and Disease Control maps for the blocks in the Rayagada district are developed from the computed values of DVI and DCI for the villages in each block in GIS environment. The vulnerability maps generated will help the district administration in readily identifying the villages in each block that have high vulnerability so that proper precautionary steps can be taken up. Similarly the control maps will help the district administration towards managing the infrastructure for disease control in an effective manner. Since the base maps are available in GIS, they can be used in dynamic nature by editing the data with updated status at any instance of time. Extension of the study in future will help in development of an information management system for optimized deployment of health services towards better treatment as well as prior control of diseases.

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