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Developing Child Malnutrition Vulnerability Spatial Model for Batticaloa District, Sri Lanka

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Abstract: ***Child vulnerability in terms of malnutrition is one of the burning issues in the DS level in Batticaloa District. Even though, many child health programmes have been introduced (both government and non-government) still child malnutrition is prevalent in many DS divisions of Batticaloa District mainly rely on Anthropometric, Geographical and Socio- economic factors. The study focuses on the development of a vulnerability index for child malnutrition age under 5 at DS divisional level of Batticaloa District. The index was derived using Principal Component Analysis using Secondary data related to nutritional and poverty factors. This GIS technique supports the mapping needs of the malnutrition distribution among DS divisions in Batticaloa District. The final vulnerability map was compared with the poverty map of the District and the combined map can be used as a spatial model for further studies related to child nutritional and health sector.***

Keywords: Child malnutrition, DS division, nutrition, poverty, vulnerability index

1. Introduction

The nutritional status of children is a most important indicator of the health of a community and can predict the future health and vigour of society. Child malnutrition, more specifically under-nutrition prevails as a global problem [1]. The World Health Organization 2002, [9] estimates that about 3.7 million deaths among young children worldwide were related to malnutrition. Similarly [2] estimated that about one-half of childhood deaths in developing countries are caused by under nutrition. Malnutrition has also been associated with mortality and morbidity in later life, delayed mental development, decreased cognitive and behavioral functioning throughout childhood and adolescence and poorer performance in school.

Higher rates of child malnutrition and child mortality are found in poor households related to quantity and insecurity regard to the quality of their diets. Poverty is a key factor affecting the underlying determinants of household food security, caring capacity, and health environments of poor households and individuals who are unable to achieve food security, have inadequate resources for care, or cannot utilize resources for health on a sustainable basis [6].

Nutritional status is typically assessed in terms of anthropometric measures i.e. underweight, stunting and wasting. The term underweight, stunting and wasting are measures of protein energy under nutrition which are used to describe children, who have a weight-for-age, height for-age and weight-for-height measurements that is less than two standard deviations below the median value of WHO international reference population. Weight-for-age (underweight) is a composite measure that takes account of both chronic and acute under nutrition. The height-for-age (stunted) index measures linear growth retardation. The proportion under this category indicates the prevalence of chronic under nutrition. Weight for- height (wasted) index examines body mass in relation to body length. The proportion in this category indicates prevalence of acute under nutrition. The table 1 presents a classification proposed by FAO.

Table 1: FAO classification of Child Malnutrition

Indicators	Low	Moderate	High	Very High
Stunting	<20%	20-30%	30-40%	>40%
Wasting	<5%	5-10%	10-15%	>15%
Underweight	<10%	10-20%	20-30%	>30%

GIS analysis can also be carried out of the spatial distribution of child malnutrition in relation to geographical boundaries in order to highlight those areas where malnutrition is most prevalent and where development assistance can have greatest impact in alleviating malnutrition. Furthermore, it can be used as a data-base, when linked to facilities such as the Geo information System (GIS) would enable those planning for the care of children in the country to target their resources to the most vulnerable group of children in need of assistance. Prediction and simulation models are based on these systems can be used for both small and simple applications such as analyzing a map and as decision-making tools into more complex issues.

2. Research Background and Study Area

The Batticaloa District occupies the Central Part of the Eastern Province. It covers land area of approximately 2624.19 square km and internal waterway of 229 square km. The District accounts for 3.8% of the Countries total Land area. The District is divided into 14 Administrative Divisions (DS Divisions) namely, Manmunai North, Koralaipattu, Eravur Town, Manmunai Pattu, Kattankudy, Koralai Pattu South, Porathivu Pattu, Koralai Pattu West, Koralaipattu Central, Manmunai West, Manmunai South West, Eravur Pattu, Koralaipattu North and Manmunai South & Eruvil Pattu (Figure 1).

Figure 1: Study Area, Batticaloa District

The District has a population of 588,202. Density of population is 224 Persons per square km. in Batticaloa District. A high density of population exists at Eravur Town DS Division and lowest density of population is at Koralai Pattu North DS Division. Major portion of the population is engaged in Agriculture while the fishing occupies the second place in the social structure. Other occupations are Industrial activities, Business and Employment in Government, Corporation and private Establishments. The Economy of the District is depending mostly on Agriculture and Fishing. The District has about 49,850 Agriculture families and about 24,943 fishing families [7].

Child vulnerability in terms of malnutrition is one of the burning issues in the DS level in Batticaloa District. Even though, many child health programmes have been introduced (both government and non-government) still child malnutrition is prevalent in many DS divisions of Batticaloa District mainly rely on Anthropometric, Geographical and Socio- economic factors.

The highest percentage of population distribution based on settlement and land area (Sq.km) falls into the Rural part of the District 69.9 and 96.99%, respectively whereas, very smaller portion falls into the urban part of the District [7]. This shows that the nutrition status of the District mainly depends on the rural population. The following table 2 shows the summary of the Nutritional Statistics of RDHS Division, Batticaloa in 2015.

According to the RDHS, Batticaloa statistics (2015) Porathivu Pattu has been identified as the DS division with highest percentage of malnutrition families (23.55%) which is followed by Koralipattu West (18.84%), Eravur Town (15.69%) and Eravur Pattu (15.51%). However other DS divisions also have the malnutrition families above 5% which show a remarkable impact in the nutritional status of the District. Based on the District Planning Unit Statistics (2015), 9 major problems were identified as contributing factors for the malnutrition problem in the District. They are, Economic reasons, Poor child care and practices, Poor feeding/Dietary behaviour, Household food insecurity, Communicable diseases, Poor housing conditions, Alcoholism and drug addiction, Poor pre-school CDC and other social factors such as Dropouts, Early marriage & Pregnancy, Poor water and Sanitation. Among these factors economic reasons contribute 40% for the prevalence of malnutrition families which is directly linked to poverty of the society.

Table 2: Nutrition Statistics -2015/ RDHS Division - BATTICALOA

	Infants		1-2 Years		2-5 Years		Under 5 Years	
	No	%	No	%	No	%	No	%
No of Under care Children	9,347	-	10,278	-	29,304	-	48,929	-
Weighed	9,101	97.36	9,775	95.1	27,441	93.64	46,317	94.66
Under weight	-	-	-	-	-	-	-	-
<-2SD	553	6.07	1,196	12.23	3,713	13.53	5,462	11.79
<-3SD	115	1.26	273	2.79	862	3.14	1,250	2.69
Stunting	-	-	-	-	-	-	-	-
Length Measured	8,623	92.25	9,775	95.1	27,441	93.64	45,839	93.68
Moderate	311	3.6	822	8.4	2,315	8.43	3,448	7.52
Severe	92	1.06	207	2.11	505	1.84	804	1.75
Wasting	-	-	-	-	-	-	-	-
Ht/Wt Measured	8,243	88.18	9,775	95.1	27,441	93.64	45,459	92.9
SAM	64	0.77	168	1.71	539	1.96	771	1.69
MAM	327	3.96	775	7.92	2,151	7.83	3,253	7.15

Source: Statistical Handbook, 2016

3. Objectives of the Study

This study aims to create Divisional Secretariat (DS) level spatial model to identify the vulnerability areas of child malnutrition (under 5) in Batticaloa District, Sri Lanka. To derive the DS division base spatial malnutrition vulnerability model, Child and Maternal malnutrition factors were used to create "Child malnutrition Vulnerability Index" (CMVI) and it is compared with poverty index of the DS divisions in Batticaloa District. The objective of this study is to use the Geographic Information System (GIS) to accurately map the precise areas where these malnourished children are. The estimates can be projected onto maps, which allow policy-makers to visually identify areas of severe child malnutrition, analyze the current situation of malnutrition and formulate geographic targeting policies aimed at assisting the neediest people in a more efficient and transparent manner.

4. Methodology

Data sources and collection

The official Secondary data from various sources were collected for the study. The nutritional data such as Underweight, Stunting, Wasting, Low Birth Weight (<5 years); Teenage Pregnancy, Anemia, Low BMI (Maternal) were collected from 2008-2015 and Moderate Acute Malnutrition & Severe Acute Malnutrition for 2013 were collected at RDHS, Batticaloa. The BMI of 14-15 years school children (2015) were collected from the joint project carried out by FAO and Ministry of Education and Poverty Index (2013) in terms of Head count Index of DS division were collected from District Secretariat, Batticaloa.

Analysis

Statistical analysis such as Correlation and Factor Analysis and Spatial analysis such as Thematic Mapping and Overlay Analysis were carried out using software SPSS 16.0 and ArcGIS 10.2. The methodology of this study can be divided into 2 categories.

1) Thematic mapping

Basic maps were created for nutritional parameters and maps were overlaid to create combined maps with new geometric classes.

2) Computation of Vulnerability Index

In order to develop a spatial malnutrition vulnerability model, child malnutrition vulnerability index (CMVI) was created using Principal component Analysis and Factor Extraction to the indicators selected for the study to compile an index on vulnerability to child malnutrition based on DS divisions. The following steps were used to develop the vulnerability index.

1) Selection of variables
2) Run correlations
3) Perform principal component and factor analysis
4) Create factor scores
5) Compute initial index
6) Compute vulnerability index
7) Classify into vulnerability classes

Similar type of methodology was adapted in a study conducted by WFP (2006) in Batticaloa District in creating Vulnerability Index to Food Insecurity.

DS divisions of Batticaloa District were classified into five groups based upon their vulnerability index score: Extremely High Vulnerability, Very High Vulnerability, High Vulnerability, Moderate Vulnerability and Low Vulnerability. This classification of vulnerability for each DS division has been presented on maps of the District where the dark shade shows highly vulnerable regions and light shade represent relatively less vulnerable regions to child malnutrition.

5. Results and Discussion

1) Mapping of Child Malnutrition Factors

Deficiency in weight-for-height, weight-for-age and height-for-age is respectively called “wasting”, “underweight”, and “stunting”. According to WHO [9], there are several obvious differences among these measures. First, one can lose weight but not height. Second, linear growth is a slower process than growth in body mass. Third, catch-up in height is possible, but takes a relatively long time even with a favorable environment. Thus, wasting reflects ‘acute’, or short-term, malnutrition whereas stunting reflects ‘chronic’, or long-term, malnutrition with underweight somewhere in between. Therefore the patterns of wasting and stunting are different when considering the target population.

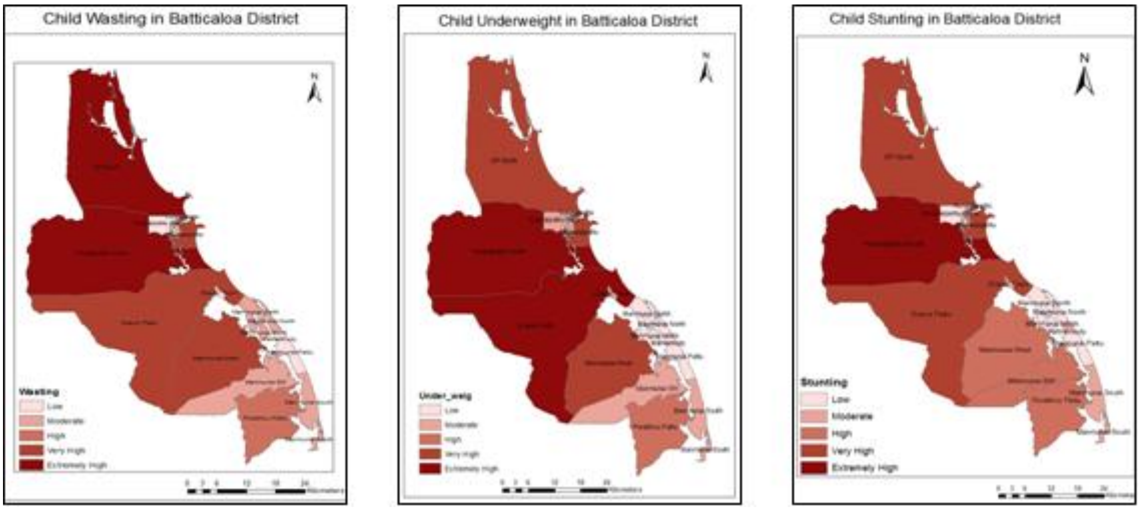

Figure 3: Maps on prevalence of child malnutrition factors

Figure 3 shows map representing DS divisional variation in child malnutrition (wasting, underweight and stunting) children below five years of age. The higher concentration of child malnutrition was observed mainly in the Koralai Pattu South DS division (23.3%, 29.2% and 24.7%) respectively. The distribution is followed by Koralai Pattu North, Eravur Pattu and Manmunai West DS divisions which fall under very high and extremely high categories.

The distribution of low birth weight is shown in Figure 4. The highest incidence in the region is in Koralai Pattu South (29.2%) which is followed by Eravur Pattu (28.0%) and Koralai Pattu North (25.8%). These regions are also high in prevalence of wasting, stunting and underweight where the low birth weight contributes a lot to the acute and chronic malnutrition factors. These types of findings also obtained from the study conducted by [5] in West African countries.

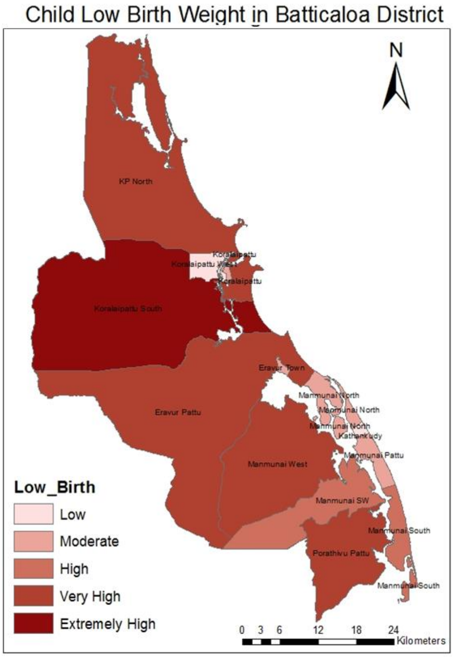

Figure 4: Map on prevalence of Low Birth Weight in Batticaloa District

Combined map of stunting and wasting is useful in order to highlight areas where children are both chronically and acutely malnourished [5], as shown in Figure 5. Based on the FAO classification (Table 1) stunting and wasting are each divided into five classes. This provides a potential 25 classes combining the two indicators. Among them, only 11 classes exist in Batticaloa District. Koralai Pattu South and Manmuani West were identified as the DS divisions where children both chronically and acutely malnourished in the District.

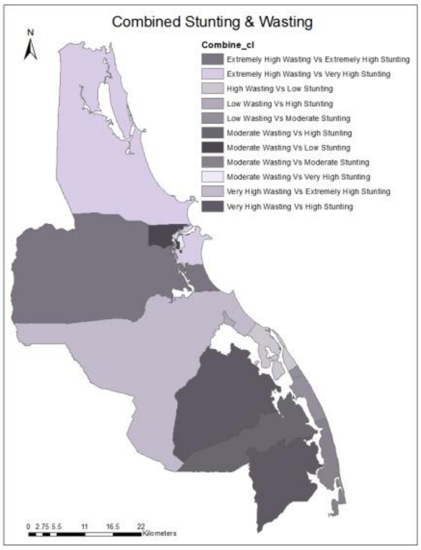

Figure 5: Map on prevalence of Combined Stunting and Wasting in Batticaloa District

6. Maternal Malnutrition Factors

Maternal nutritional factors play a major role in determining child malnutrition level. Because adult malnutrition especially, maternal creates less productive child nutrition which has severe and permanent consequences for physical and intellectual development. Babies born to severely undernourished and anemic mothers are at higher risk of being underweight and dying soon. Even though they survive, they will never make up for the nutritional shortfalls at the very beginning of their lives. Adults who were malnourished as children are less physically and intellectually productive, have lower educational attainment and lifetime earnings, and are affected by higher levels of chronic illness and disability [5].

Three types of maternal factors were used in this study namely teenage pregnancy, maternal anemia and maternal low BMI. These 3 factors contribute a lot in determining the birth weight of children as well as indirectly impact of acute and chronic impacts on nutritional status of under 5 children. Figure 6 shows the distribution pattern of maternal malnutrition factors among DS divisions.

Koralai Pattu North and South show the highest percentage of teenage pregnancy 22% and 18% respectively. Teenage pregnancy is considered as the pregnant mothers who are under 20 years of age. This is an alarming issue in the region where it directly impact in the maternal BMI as well as Maternal anemia that leads to low birth weight of children. Measures should be taken to control the teenage pregnancy to maintain the maternal nutrition in the region.

7. Moderate and Severe Acute Malnutrition

Moderate and Severe Acute Malnutrition give a picture of development of the impact in child malnutrition in different stages (Figure 7&8). According to WHO standards Acute Malnutrition is calculated by weight/height^2. Moderate level falls <2SD and Severe <3SD. The DS divisions fall under the category of high and extremely high classes should be taken immediate remedies to overcome the child malnutrition status of that region. The figures (7 &8) clearly show how the MAM and SAM vary among the DS levels and also visible that impacts the BMI of adolescence children (14-15 years). The maps clearly present that the MAM and SAM increases with the age category from 0-1 to 2-5 years also give similar results in BMI of 14-15 years children.

8. Classification and Mapping of the Vulnerability Index Scores

The basic thematic maps show many factors give an impact in the prevalence of child malnutrition in among DS divisions in Batticaloa District. However, rather than using various abstract variables in the form of numbers or proportions separately, a single index quantifying the complex conditions can be more meaningful in understanding area-level

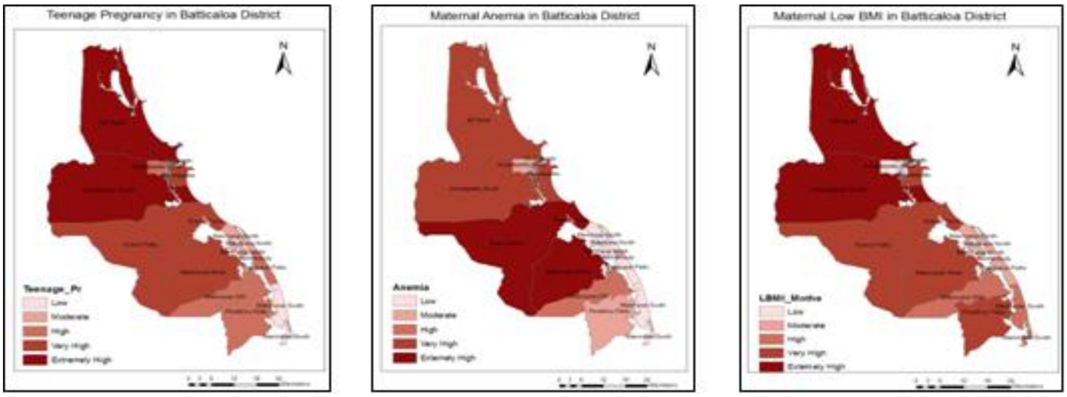

Figure 6: Maps on prevalence of maternal malnutrition factors

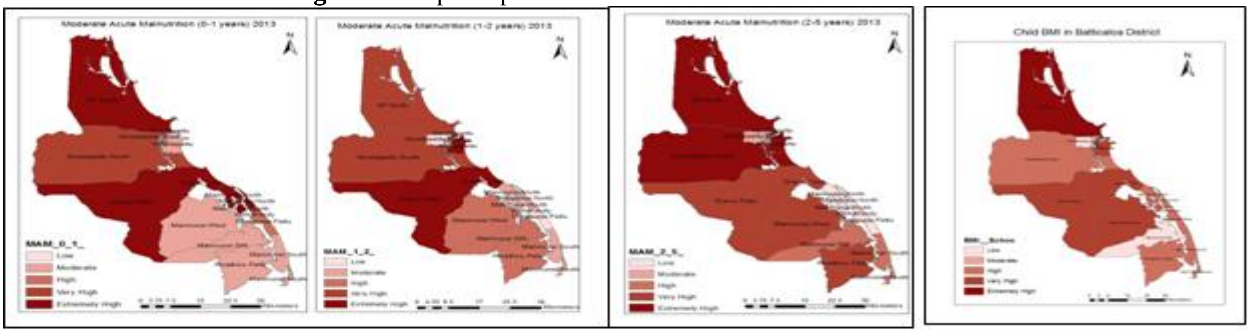

Figure 7: Maps on Moderate Acute Malnutrition and BMI of 14-15 years old children in Batticaloa District

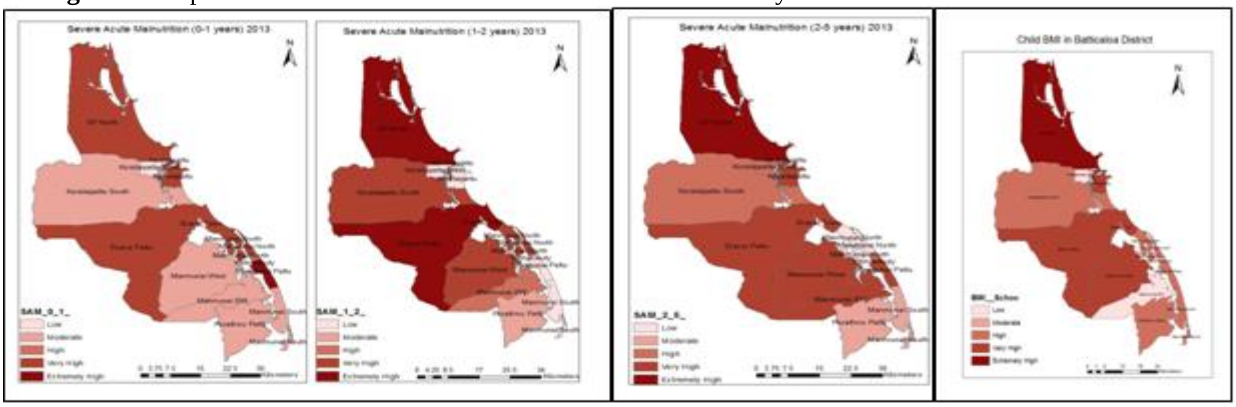

Figure 8: Maps on Severe Acute Malnutrition and BMI of 14-15 years old children in Batticaloa District

factors that provides the vulnerability of the child malnutrition. Such an approach not only allows comparisons across regions, but also helps to design theories and conceptual frameworks of a complex phenomenon to take remedial measures. Many studies have used this type of indices to compute the vulnerability level in their researches [4], [8]. The malnutrition level depends on numerous factors or variables. However, these variables may be correlated to each other. The index was derived from a Principal Components Analysis (PCA) of census data from RDHS, Batticaloa on DS divisional level. Data on 8 variables measuring multiple aspects of malnutritional status such as underweight, stunting, wasting low birth weight, BMI of 14-15 years children, maternal anemia, teenage pregnancy and low maternal BMI were utilized to extract to reduce those into a set of few factors. Several statistical tests such as Correlational Matrix, KMO,

Table 3: Total Variance with Eigen Values

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.083	76.038	76.038	6.083	76.038	76.038	4.649	58.118	58.118
2	.843	10.541	86.579	.843	10.541	86.579	2.277	28.461	86.579
3	.484	6.050	92.630						
4	.374	4.670	97.299						
5	.134	1.674	98.973						
6	.061	.757	99.729						
7	.013	.158	99.888						
8	.009	.112	100.000						

Extraction Method: Principal Component Analysis.

Bartlett's Test of Sphericity were used to assess the appropriateness of using PCA.

Two factors were discovered which together explained 86% of the total variation which explained as Eigen value with its corresponding weight (Table 3).

The Scree plot (Figure 9) and Rotational Matrix (Table 4) were used to ensure the factor loading to each component. The rotated component matrix showing the correlations among indicators and factors.

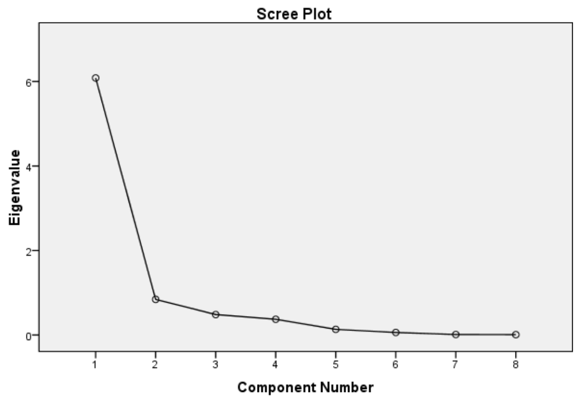

Figure 9: Scree Plot

Table 4: Rotational Component Matrix

Rotated Component Matrix[a]

	Component	
	1	2
Under weight	.880	.425
Stunting	.837	.416
Wasting	.848	.467
Low Birth Weight	.945	
BMI_School		.917
Anemia	.585	.569
Teenage Pregnancy	.562	.680
Low BMI_Mothers	.941	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

a. Rotation converged in 3 iterations.

To formulate a single index indicating area deprivation, there are two methods namely, z-score and factor analysis. Factor scores were utilized to derive standardized indices (Table 5). The extracted 2 factors were classified as child factors and maternal factors that contribute to vulnerability of child malnutrition.

Table 5: Factor Scores

DSD	F1	F2
Koralai Pattu West	-0.9859	-0.6673
Koralai Pattu Central	-1.6399	1.0725
Eravur Town	-0.9425	-0.2740
Manmunai Pattu	-0.8175	-0.4302
Manmunai North	-0.6250	-0.5909
Kathankudy	-0.3080	-1.0627
Manmunai South & Eruvil Pattu	-0.0067	-1.0301
Manmunai South-West	0.7379	-1.2029
Koralai Pattu	-0.1840	1.3078
Porativu Pattu	0.6708	-0.3357
Koralai Pattu North	-0.1941	2.0240
Manmunai West	1.3481	0.0791
Eravur Pattu	1.6621	0.0007
Koralai Pattu South	1.2847	1.1099

Factor 1: Child Factors & Factor 2: Maternal Factors

Scores for each factor at DS level were calculated as a fraction of the total variation explained by each principal component which is calculated for 14 DS divisions.

IN_1 = (58.118/86.579) (Factor 1 score) + (28.461/86.579) (Factor 2 score)

Finally, the vulnerability index was prepared as a linear combination of factors extracted (WFP, 2006). The value of the index can be positive or negative, making it difficult to interpret. Therefore, a Standardized Index was developed, the value of which can range from 0 to 100, using the formula (Krishnan, 2010):

$$CMVI = \frac{(IN\ of\ DSD\_1 - Min\ IN)}{(Max\ IN - Min\ IN)} \times 100$$

The results were classified into equal 5 classes of (0-20%) Low Vulnerability, (21-40%) Moderate Vulnerability, (41-60%) High Vulnerability, (61-80%) Very High Vulnerability and (81-100%) Extremely High Vulnerability and it is presented in DS division maps (Figure 10). The DS divisions fall into Extremely High Vulnerability are shown by dark colour on the map.

Figure 10: Map on prevalence on CMVI in Batticaloa District

DS Divisions fall into the Vulnerability Classes

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a) Extremely High Vulnerability:
  - Koralai Pattu South
  - Eravur Pattu
  - Manmunai West
b) Very High Vulnerability
  - Koralai Pattu North
c) High Vulnerability
  - Porativu Pattu
  - Koralai Pattu
  - Manmunai South-West
d) Moderate Vulnerability
  - Manmunai South & Eruvil Pattu
e) Low Vulnerability
  - Kathankudy
  - Manmunai North
  - Manmunai Pattu
  - Eravur Town
  - Koralai Pattu Central
  - Koralai Pattu West

9. Child malnutrition and Poverty

The household income and expenditure survey (2002) revealed that about 1/4th of the population in Sri Lanka is classified as poor. It is also can be strongly linked with food insecurity [8]. The prevalence of food insecurity and poverty varies considerable across the geographical regions which were identified during the Vulnerability analysis and Mapping project conducted by WFP in 2006.

The poverty shows a wide distribution pattern among DS divisions. The poverty is measured in terms of Head count Index. The statistics of spatial distribution in poverty [3] shows that Batticaloa District falls into the category of Extreme poverty along with Mannar, Mullaitivu and Moneragala district. The map also reveals significant geographical disparity among DS divisions in some districts. Poverty rates in DS divisions in Batticaloa vary widely from 5.3 percent to 45.1 percent in Manmunai-west. Figure 11 shows the poverty disparity among DS divisions in Batticaloa District based on the Head Count Index (2013).

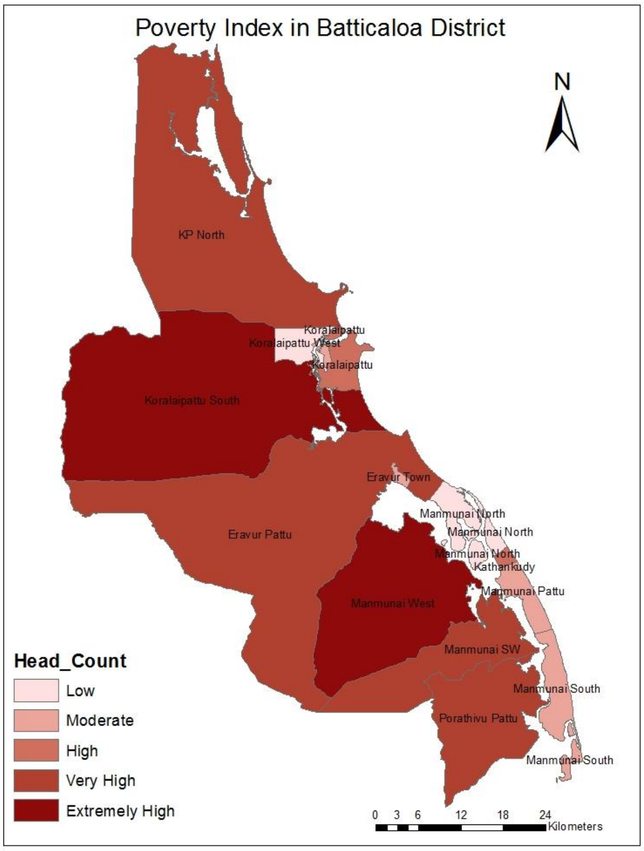

Figure 11: Map on prevalence on Poverty Index Batticaloa District

The developed map in Child Malnutrition Vulnerability Index was compared with Poverty Index map of Batticaloa District (Figure 12). The maps were combined and output produced with the combination of vulnerability and poverty classes. This type of comparison also carried out by [5] in comparing child nutrition and agricultural production in West African Countries.

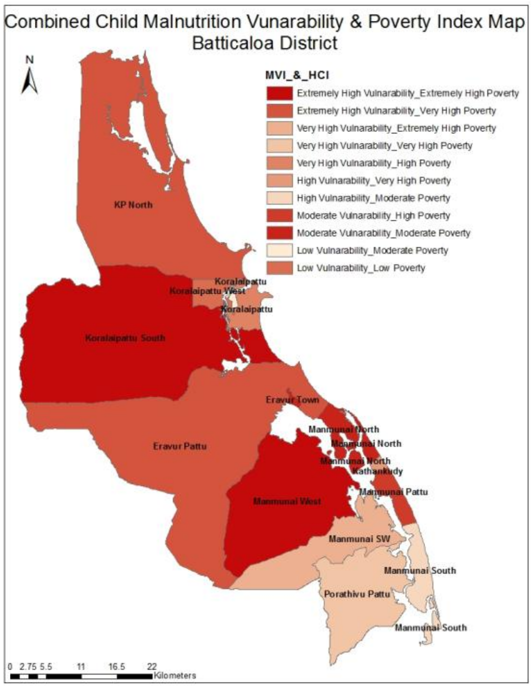

Figure 12: Map on prevalence on Combined Child Malnutrition and Poverty Index Batticaloa District

The comparison show high correlation between the vulnerability of malnutrition and poverty in the DS divisions of Batticaloa District. Among possible 25classes 11 classes are available in the district. The Korali Pattu South DS division falls into the extremely high vulnerability and poverty category where the remedies should be taken immediately to eradicate poverty and malnutrition vulnerability, where the Manmuani West and Koralai Pattu North follows respectively.

10. Conclusion

The study is conducted to classify the DS divisions of Batticaloa District according to their relative vulnerability to child malnutrition under 5. The maps illustrated considerable differences in the vulnerability level among DS divisions. The study also intends to identify the relationship between the poverty and malnutrition vulnerability by overlaying the two maps. Considerable output was obtained from the overlaid map that the Koralai Patttu South & Manmunai West fall into Extremely High Vulnerability_ Extremely High Poverty and Eravur Pattu & Koralai Pattu North fall into Extremely High Vulnerability_ Very High Poverty categories. It can be concluded that, the spatial model map gives an idea to identify the vulnerability places of child malnutrition under 5 and it can be used as a basic model for further development in child health sector.

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