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Food Insecurity and Vulnerability Assessment for Sri Lanka — Ranjith Premalal De Silva

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Hector Kobbekaduwe Agrarian Research and Training Institute (HARTI)

ES:GCP/RAS/170/JPN
Field Document No. 9

FAO/GOVERNMENT COOPERATIVE PROGRAMME

DEVELOPMENT OF A VULNERABILITY INFORMATION BASE, MAPPING AND DISSEMINATION SYSTEM FOR ASIA IN SUPPORT OF THE FOOD INSECURITY AND VULNERABILITY INFORMATION AND MAPPING SYSTEM (FIVIMS) - PHASE II: GCP/RAS/170/JPN

FOOD INSECURITY AND VULNERABILITY ASSESSMENT FOR SRI LANKA

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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TABLE OF CONTENTS

FOREWORD

It is with pleasure that I note the completion of the study on Food Insecurity and Vulnerability Assessment for Sri Lanka at district level as per the general methodology outlined in the Manual of Operations of Sri Lankan FIVIMS. The Manual of Operations was developed in 2003 as a guideline document for National FIVIMS. The study reported in this book deviates from the methodology outlined in the FIVIMS Manual of Operations, on the selection of spatial units for the analysis of structural vulnerability. As the initial stage, the entire analysis of this study was based on the data at district level and accordingly, there was no stratified sampling involved in the study. The number of variables used at district level exceeds 40 and it covered almost all the variables proposed in the Manual of Operations. In addition, results of the study conducted at Divisional Secretary's Division level for Moneragala district with 25 selected variables are also included in this book as a pilot study.

The Food Insecurity and Vulnerability map for Sri Lanka would not claim any merits in the process of developing implementation strategies for intervention. It was made clear in this study that as it is required to identify the causative factors for food insecurity and vulnerability in terms of three main categories of factors or variables namely, on Food Availability, Food Accessibility, and Nutritional Status and Health. It was also understood that minor differences of the resultant map products could occur due to the differences in adopted classification methodologies.

The results of this study indicate the status of food insecurity and vulnerability and the causative factors to initiate reduction interventions. The same methodology could be employed for detailed assessment of food insecurity with a limited number of variables at higher spatial resolution.

I wish to thank Mr. Naoki Minamiguchi of Asia FIVIMS for providing me the opportunity to conduct this study and assisting me to produce this revised edition (first edition: January, 2006). I also wish to thank Sri Lanka FIVIMS for the support extended to me in publishing this book. I also wish to thank Mr. Lasantha Mallawarachchi and Mr. Ajith Jayasekare for their untiring efforts for data collection and analysis.

I sincerely hope that this effort would contribute towards supporting the reduction of food insecurity and vulnerability in Sri Lanka.

Dr. Ranjith Premalal De Silva

EXECUTIVE SUMMARY

Climatic conditions prevailing in Sri Lanka are suitable for production of most of the agricultural food crops. However, in terms of national food security, problems exist in some parts of the country. Food insecurity indicates the physical unavailability of food, lack of social or economic access to adequate food or inadequate food utilization resulting in the conditions of undernourishment or malnutrition. Vulnerability to food insecurity refers to a wide range of factors which make people at risk of becoming food insecure. Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) in Sri Lanka helps to identify areas highly vulnerable to food insecurity. It also provides details on the causes of vulnerability. Food insecurity and vulnerability is, in the Sri Lankan context, described by food availability, affordability, accessibility or other factors related to food production and distribution. Identification of those factors causing food insecurity and vulnerability will assist policy and decision makers to resolve the issues associated with the vulnerable areas and to better identify and characterize the problems.

Due to limited data availability at various spatial scales, it was decided to evaluate the food insecurity and vulnerability status of the country at the district level. Accordingly, an index of food insecurity and vulnerability was developed for 17 districts except for the districts in Northern and Eastern provinces. Secondary data published by the Department of Census and Statistics and other government institutes were analysed to determine the status of food insecurity and vulnerability. The available data were categorized into four groups of factors, namely food availability, accessibility, affordability and other related variables. Contribution of each variable to food insecurity or vulnerability was estimated by using factor analysis techniques separately for these categories.

Finally, the derived factors in each category were subjected to the second stage of factor analysis to derive composite index of food insecurity and vulnerability. The districts were classified according to the derived indices of separate categories as well as composite index using ArcGIS. The Geographical Information System was used to identify spatial relationships required for resource allocation, food availability and various other related factors. It helped to analyse and interpret spatially distributed data and results as well as visualize outputs in a more understandable form. In addition, a digitized district map of Sri Lanka was used as the spatial demarcation for the districts in the study. Maps indicating food insecurity and vulnerability for each category and an overall composite index were prepared using the calculated values of the food insecurity and vulnerability indices for all 17 districts as well as the classification types of natural break and equal interval. As a result, five food insecurity and vulnerability classes were identified such as Least Vulnerable, Less Vulnerable, Moderately Vulnerable, Vulnerable and Critically Vulnerable.

In addition, Divisional Secretary Division based food insecurity and vulnerability analysis was conducted for Monaragala district to demonstrate the application of the developed methodology at different spatial scales.

The outputs reveal that food insecurity and vulnerability differ from area to area depending on variables considered for estimation. That is to say that areas identified as food secure within the framework of food availability could be classified as food insecure areas in another category of variables. Hence, the category-wise analysis is very crucial and helps to identify different factors to be considered when planning interventions and mitigation measures related to food insecurity and vulnerability. Also the composite vulnerability index gives the general idea of the country and is important for management and planning, especially for policy makers.

INTRODUCTION

1.1 Country Profile of Sri Lanka

1.1.1 Geography

Sri Lanka is a South Asian island in the Indian Ocean about 32 km from the southeastern tip of the Indian subcontinent. It is located between 5° 55' to 9° 50' of North Latitude and between 79° 42' to 81° 53' of East Longitude. Sri Lanka maritime frontier extends to about 517,400 square kilometers of Indian Ocean. Maximum length of Sri Lanka is 432 kilometres from North to South and the maximum width is 224 kilometres from West to East. The total area of the country is 65,610 square kilometres and includes 62,705 square kilometres of land area and 2,905 square kilometres of inland waters. About four-fifths of the Island is flat or with gentle slope. The elevation increases rapidly at the south central area of the country from sea level to 2,527 meters, which is the highest point of the island. High elevation changes within a short distance can be seen in the country.

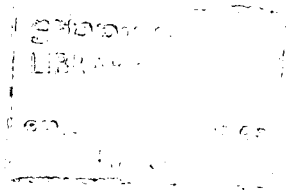
1.1.2 Climate

As it is in tropical region of the world, Sri Lanka undergoes sub tropical climatic conditions. The average temperature is about 27 °C. The temperature varies from 24.4 °C to 31.4 °C in the low country and 17.1 °C to 26.3 °C in the hill country (Central Bank Report, 2004). There is a large temperature difference between the high elevation south central area of the country, and the low elevation area, which is especially caused by the rapid elevation change.

Sri Lanka shows a well-distributed rainfall pattern and there are two major monsoon periods in the country. The North-East monsoon brings rain mainly to the dry zone of the country from November to April while the South-West monsoon brings rain to the wet zone from May to October. The rainfall in Sri Lanka is around 2,425 mm and 1,470 mm in the wet and dry zones, respectively, and the average being around 1,700 mm. Semi arid zone receives only about 1,000 mm of rain annually.

1.1.3 Demography

The Statistical Abstract in 2004 shows that the total population of the country is about 19.46 million and that the population growth rate in year 2005 is estimated as 0.79% (The World Fact Book; on line). With the limitation of the area and the high population growth rate, the average population density has shown a rapid increase in the last few decades and it was 310 persons per square kilometer (Central Bank Report, 2004) in year 2004. Population distribution comprises of 14.63% in urban areas, 80.04% in rural areas and 5.33% in the estate sector (Central Bank Report, 2004) and it shows an obvious uneven distribution. As an example, the population density in Colombo and Monaragala districts are 3,305 and 72 heads per square kilometer, respectively.



According to the Central Bank Report 2004, the crude birth rate of 2003 is 18.9 per 1,000 population and the crude death rate is 5.9 per 1000 population. The infant mortality rate in year 2003 is 11.2 per 1,000 live births but it shows a decreasing trend according to the past figures. It was 17.7 per 1,000 live births in 1991 and 13.3 per 1,000 live births in 2000 (Statistical Abstract, 2004). The World Fact Book shows that the values of life expectancy at birth in Sri Lanka are above those of other developing countries. It is 70.7 years for males, and 75.86 years for females and the average of these two figures is 73.17 years in year 2005 (The World Fact Book, on line).

1.1.4 Administrative Structure

The Central Republic Government is involved in most of the administration of the country. It is centralized around the parliament, which includes 225 members, and out of that 196 members are popularly elected in multi-seat constituencies and the rest 29 by nationwide proportional representation for a period of six years. The chief of state and also the head of the government is the President, who is also elected for a six-year term by popular vote.

The country is divided into 9 provinces and again those provinces are sub divided into 25 districts (Figure 01), then into 328 Divisional Secretariats and again into 14,016 Grama Niladari Divisions. Table 01 shows the arrangement of these administrative divisions of the country.

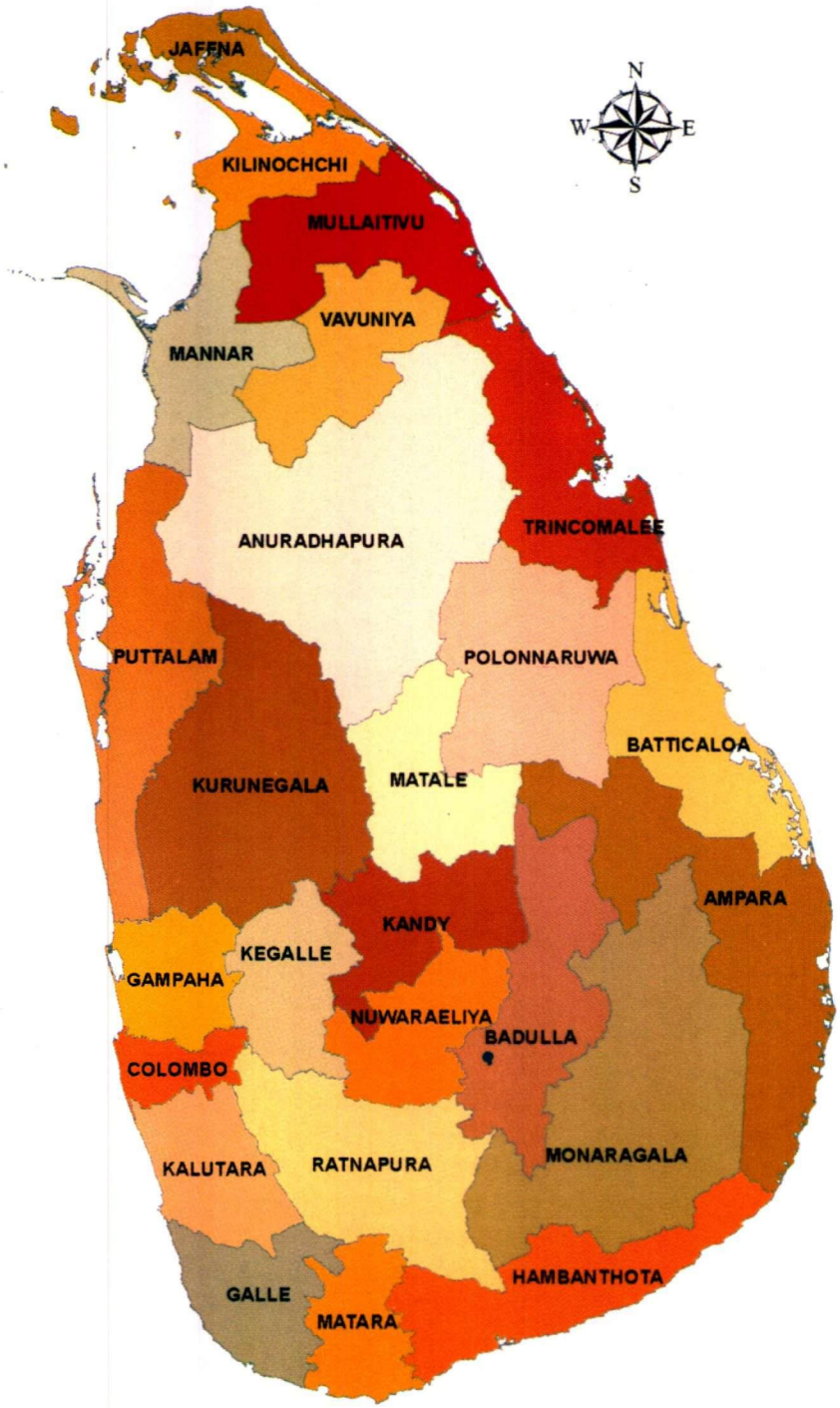


Figure 01: Administrative district map of Sri Lanka

Table 01: Administrative divisions of Sri Lanka

Provinces	Districts	Number of Divisional Secretariats	Number of Grama Niladari Divisions
Northern Province	Jaffna, Mannar, Vavuniya, Mullative, Kilinochchi	32	1148
Southern Province	Galle, Matara, Hambantota	46	2224
Eastern Province	Batticaloa, Ampara, Trincomalee	45	1086
Western Province	Colombo, Gampaha, Kalutara	40	912
Central Province	Kandy, Matale, Eliya	36	2496
North-Central Province	Anuradhapura, Polonnaruwa	29	2158
North-West Province	Kurunegala, Puttalam	46	2117
Sabaragamuwa Province	Ratnapura, Kegalle	28	886
Uva Province	Badulla, Monaragala	26	989

1.1.5 Social and Cultural Background

The people of the country are mainly included into four ethnic groups and the Sinhalese comprises of about 75 percent of the population. Other major groups are Tamils, Muslims and Burgers. The majority of the population is Buddhists who represent about 70 percent of the total. Others are Hindus, Christians and Muslims. The official and national languages of Sri Lanka are Sinhala and Tamil. However, English is most commonly used as an official language.

1.1.6 Economy

Sri Lanka is a low-income development country. Human Development Index (HDI) in 2005 published by the UNDP ranks Sri Lanka at the 93rd position under the category of medium human development (Human Development Report, 2005).

The economy of the country is mainly based on agriculture and out of that a large proportion comes from exporting agricultural crops such as tea, rubber, and coconut, which grow especially in plantations in large scale. However, after introducing the open economy to the country, within the last two decades, the textile and garment sector has become the largest export sector of Sri Lanka, contributing to about 63% of the GDP. Food processing, food and beverage production, telecommunication, insurance and banking, petroleum refining, and gems, jewellery and mineral industries give a considerable contribution to the Sri Lankan economy as well.

The GDP growth rate was maintained at an average of 5.5% in the early 1990s. Subsequently, it lowered due to several conditions such as severe droughts, power shortages, severe budgetary problems, the global economic slowdown and also due to the

civil war of Northern and Eastern provinces. Thus, the economy shrank with the GDP growth rate being – 1.4% in year 2001. However, it increased up to 5.2% in 2004 (The World Fact Book, on line), even with the serious damages caused by the Tsunami disaster.

The total labor force of the country is about 7.26 million in 2004, out of which about 0.8 million workers were employed abroad (The World Fact Book, on line) contributing considerably to the improvement of the national economy. However, it was found that the unemployment rate remained high at 7.8% in year 2004.

1.2 Overview of Food Security

Food is a basic need of humans and the main source of energy and nutrition. The recommended energy requirement of an individual is described as the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition, consistent with long-term good health, as well as allow for the maintenance of economically necessary and socially desirable physical activity (Recommended Energy and Nutrient Intakes, 2002). It means the energy requirement is varying according to several factors such as age, sex, activities, etc., and the intake of nutritious food in necessary amounts is a very important aspect with respect to the human health.

Global food production has grown faster than the population increase since 1950s and at present, the production is above the need of food for global consumption. However, about one sixth of the global population remains underfed, and still there are countries with significant malnutrition problems (State of Food Insecurity, 2005). So food security is one of the major topics of the global community, which can be achieved globally.

At the World Food Summit in 1996, it was agreed that food security exists when all people, at all times, have physical, social and economical access to sufficient, safe and nutritious food to meet their dietary needs and food preferences according to their requirements for an active and healthy life (World Food Summit Plan of Action, 1996). Household food security is an application of this concept at the family level. A further breakdown is possible looking at individuals within the household, particularly relevant to nutritional outcomes.

One of the main goals of the Summit is to achieve food for all but food insecurity continues to prevail in many parts of the world. Food insecurity exists when people are undernourished as a result of the physical unavailability of food, their lack of social or economic access to adequate food, and/ or inadequate food utilization. On the other hand, food insecure people are those individuals whose food intake falls below their minimum calorie (energy) requirements, as well as those who exhibit physical symptoms caused by energy and nutrient deficiencies resulting from an inadequate or unbalanced diet or from the body's inability to use food effectively because of an infection or a disease (FIVIMS, online). Vulnerability refers to the full range of factors that place people at risk of becoming food-insecure. The degree of vulnerability of individuals, households or groups

of people is determined by their exposure to the risk factors and their ability to cope with or withstand stressful situations (FIVIMS, online).

1.3 Situation in Sri Lanka

In the last few decades, the human development levels in Sri Lanka have improved. However, malnutrition remains high in the country as per the standards of WHO and FAO. Children under the age of 5 years and pregnant and lactating mothers are the most sensitive groups for the malnutrition condition. However, most of the social, economical and health indicators in Sri Lanka are higher than those of the other countries in the South Asian region.

In terms of food security of the nation, problems exist in some parts of the country. Therefore, ensuring food security is a very significant aspect of government economic policy in order to make a healthy human resource available for the whole country. Poverty has been identified as a major factor for food insecurity. Even when food is available, food insecurity exists when people have no economical strength to purchase food. In Sri Lanka, there are several measures already adopted to minimize food insecurity among vulnerable groups and to decrease poverty of the people by giving income support to them and promoting their production and development activities. The "Samurdhi Programme" is one of the major actions taken by the Sri Lankan government to increase the income and quality of life among poor communities. Also governmental and non-governmental organizations have introduced several national social welfare programs in this regard. In particular, the Sri Lankan government promotes agricultural production by several ways such as increasing extension services, giving fertilizer subsidies to farmers, etc. However, there are problems associated with launching of these projects in Sri Lanka.

Overall climatic conditions prevailing in Sri Lanka are suitable for production of most agricultural food crops and livestock. But the agricultural sector is becoming risky or vulnerable due to the changing situations of the environment. The climatic changes directly affect food production. As an example, farmers who practice rain-fed cultivation are severely affected by drought conditions. There is increasing concern about the effects of global warming, especially on agriculture. Droughts and severe storms are another serious threats to future food security. Even in Sri Lanka, it has been reported that the extremes of weather conditions are more frequent in the recent decades in comparison to the similar periods of the beginning of the century (Premalal, 1993). Accordingly, crop losses due to climatic extremes are occupying an increasing trend even with the genetically improved food crop varieties with stronger resistance to droughts and floods.

Further, continuous cultivation of agriculture lands with heavy loads of agro-chemicals affects the quality of the food crops harvested. Excessive use of inorganic fertilizers and frequent cultivation on the same lands are the major reasons for land degradation, in addition to the soil productivity deterioration by extreme weather phenomena. These are adversely influencing the agricultural production. In addition, the non-agricultural sector

demands more land with higher returns. Fragmentation of agricultural land holdings also contributes towards lower production due to lowering of inputs and technology applied. All these factors leading to low agricultural production and productivity could adversely affect the food security of the nation.

The education level of the people in the country is another issue, which can be considered in relation to food insecurity. In this regard, past governments took several actions to increase the education level and the literacy rate of the nation. Free education from primary level up to university is a major action taken by the government in addition to several programs within the educational system such as providing free text books, free meals, free uniforms, subsidies for transport and also giving financial support through scholarships, etc. The national literacy rate has continuously been growing from 69% in 1953, 77% in 1963, 78.5% in 1971, 87.2% in 1981 and 92% in 2003 (Statistical Abstract, 2004).

In addition to the above conditions, considerable changes in the sectors related to food supply and demand and price effects may affect undernourishment. Therefore, possible future crisis situations such as wars, embargoes, social instability, natural disasters or environmental or safety related crisis should also be taken into account when considering food insecurity.

Inadequate access to food and poor nutrient utilization are the major causes of food insecurity in Sri Lanka. As an initial approach to resolving the problem, it is very important to identify food insecure and vulnerable areas in the country as well as factors responsible for food insecurity and vulnerability in order to assist policy and decision makers with better targeting, effective resource mobilization, improved policy formulation, and timely interventions.

It is clear that a number of spatially distributed factors could contribute to the status of food security of the country. These variables can be viewed in terms of generalized spatial and temporal averages to determine the general status of food security in the long run, while dynamic changes of these variables could be considered in short term food security issues.

Geographical Information Systems (GIS) have been widely used to analyse and interpret spatially distributed data and visualize results in a more understandable form. Since food insecurity varies due to a number of spatially varying factors, GIS were considered as a useful tool in identifying spatial relationships required for resource allocation, food availability and various other related factors. Mapping food insecurity and vulnerability is helpful in demarcating areas, which are likely to suffer due to short-term fluctuations and identifying contributing factors and the communities which continue to be deprived of food in order to implement intervention strategies.

METHODOLOGY

The methodology outlined in the FIVIMS Manual of Operations for Sri Lanka (2003) was adopted for the study with some modifications in order to adjust to the available resource base for the study. In this study, there was no provision for collection and compilation of primary data and hence, all the data were acquired from secondary sources. The main difference in the adopted methodology for this study compared to the methodology given in the Manual of Operations is that there was no field data collection involved in this study.

2.1 Data Collection

Data were collected for the entire country excluding Northern and Eastern provinces. Most of the data available for the eight districts in Northern and Eastern provinces were estimated values based on past figures, whereas some other categories did not have sufficient data due to the situation prevailed in the area. This study covers 17 administrative districts in the other seven provinces of Sri Lanka (i.e., Western, Southern, North Central, Central, North-West, Sabaragamuwa, and Uva provinces).

There are numerous categories of data available as secondary data, which are collected and published by different organizations or agencies, namely:

- Department of Census and Statistic (DCS)
- Department of Agriculture (DOA)
- Department of Animal Production and Health
- Ministry of Health Nutrition and Welfare
- Ministry of Education and Higher Education
- Registrar General's Department
- Road Development Authority (RDA)
- Natural Resource Management Centre (NRMC)
- Central Bank of Sri Lanka
- Department of Community Medicine, Faculty of Medicine, University of Peradeniya

Most of the data published by the agencies have been collected based on the administrative divisions such as districts, divisional secretariats and Grama Niladari divisions, etc., with the exception of climatic data, health and demographic survey data, etc., which have been collected based on different spatial units or zones.

2.2 Database Management

Microsoft Excel software was used to manage and process the data in the database. The available district level data were categorized under four main themes:

- Food availability based on food production
- Food accessibility and affordability
- Health and nutritional status
- Other related variables that have an influence on food insecurity and vulnerability

The variables used in the study and the categorization of those variables are shown in Table 02.

There were several issues related to the spatial units for which data have been collected. Those data were transferred into respective administrative divisions based on the area or the population as a weighted average.

The Census of Agriculture and Livestock conducted in 2002 by the Department of Agriculture categorizes Mahaweli System H as a separate zone which includes parts of Anuradhapura, Matale and Kurunegala districts as shown in Figure 03. All the crop production data and livestock data have been collected and compiled for the Mahaweli System H. The proportional area contribution to Mahaweli System H by the above three districts were taken into consideration when area weighted averages were calculated to compute the values corresponding to each district.

Table 02: Main categories of data and the variables used in the study for district based analysis

Category	Variables
Food Availability based on food production	Population Number of agriculture holdings Annual crop production Paddy production Vegetable production Other cereal production Other crop production namely pulses, spices, oil crops and tuber crops Fruit crop production Livestock population and production Milk production including both cattle and buffaloes Eggs production Number of slaughtered animals Animal population namely goat, sheep, pig, chicken, ducks, cattle and buffaloes Annual rainfall and rainfall distribution
Food Accessibility and Affordability	Road length Type A road Type B road Railway length Household income Household expenditure Food Ratio (FR= Expenditure on food items/ Total expenditure) Expenditure on food items
Health and Nutritional Status	Live birth rate (per 1,000 people) Crude birth rate (per 1,000 people) Crude death rate (per 1,000 people) Infant mortality rate (per 1,000 live births) Rate of low birth weight infant (per 1,000 people) Maternal death rate (per 10,000 live births) Percentage of people with safe drinking water Prevalence of diarrhea Percentage of children stunted (below 5 years old) Percentage of children wasted (below 5 years old) Percentage of children underweight (below 5 years old)
Other Related Variables	Number of hospitals (per 1,000 people) Number of beds in hospital (per 1,000 people) Number of medical officers (per 1,000 people) Unemployment % Number of schools (per 1,000 people) Literacy rate (%) Percentage of people who were not attending schools Households with permanent housing units % Households with permanent floor material % Households with permanent wall material % Households with permanent roofing material % Percentage of housing units lighting by electricity

Category - continued	**Variables** - continued
	Households with using convenient fuel % (Gas/ Electricity) Percentage of housing units with toilets

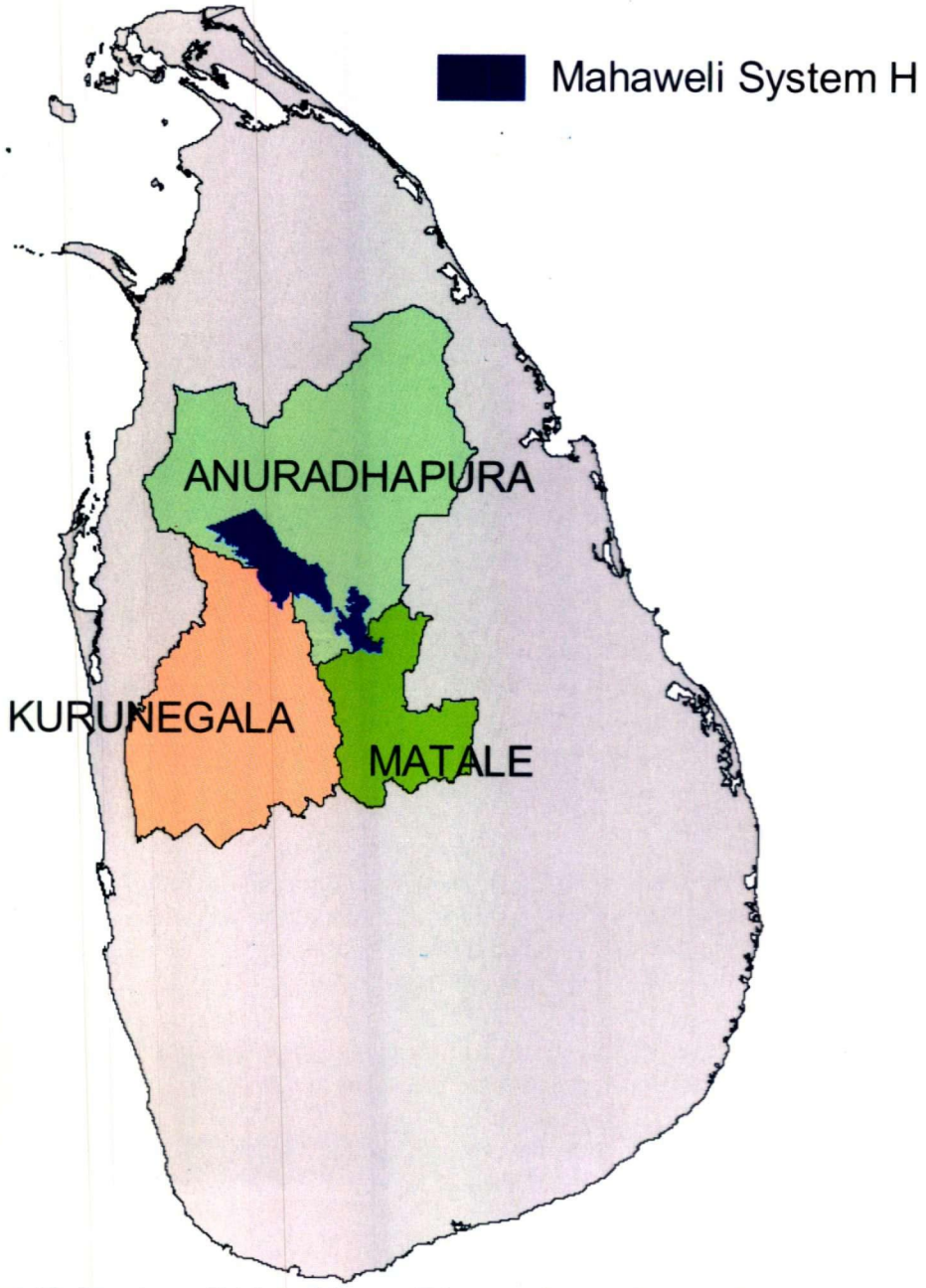


Figure 03: Locations of Mahaweli System H in Anuradhapura, Kurunegala, and Matale districts

Rainfall data were used in this study to represent the climatic variability which affects food production. In order to take into account the distribution of rainfall within a given year, in addition to the average annual rainfall, Modified Fournier Index (MFI) (Wickramasinghe & Premalal, 1989) was used. The MFI calculation is given in Equation 01. However, climatic data related to rainfall were not collected based on administrative districts. Agro-ecological regions are the relevant spatial units for rainfall data. Therefore, the data for these two variables were obtained from the agro-ecological map (2004), which was published by the Natural Resource Management Center of the Department of Agriculture and is shown in Figure 04. Area weighted averages were used to extract data for climatic variability based on rainfall in each district.

$$MFI = \sum_{n=1}^{12} \frac{p^2}{P} \quad \text{(Equation 01)}$$

MFI = Modified Fournier Index
p = Monthly Average Rainfall
P = Annual Rainfall

The length of railway in each district was calculated by using geo-processing techniques from Sri Lanka railroad map shown in Figure 05. The density of railroads is also considered as a variable in food accessibility.

The collected data were converted to comparable units based on the population of each district and the total area, depending on the data type. Subsequently, these data were arranged in a hierarchical order so that food insecurity increases with the increasing level of each variable. This was done by subtracting the variable values of each district from the corresponding maximum value for that variable. In this case, districts with higher food security status receive zero value and values for other districts were calculated accordingly.

Total population was taken as a density for the district by dividing the total population by the area of the district and given as the number of heads per square kilometer. Further, the number of agriculture holdings was calculated per 1,000 population in order to take the total number of agriculture holdings as an input variable. The direction of data distribution was changed by subtracting the number of agriculture holdings of each district from the highest value shown in Kurunegala district because this particular variable shows a negative relationship with food insecurity.

All the crop and livestock production data were calculated based on production units (kilograms and liters) per person excluding fruit production, which was taken as kilocalories of energy per person.

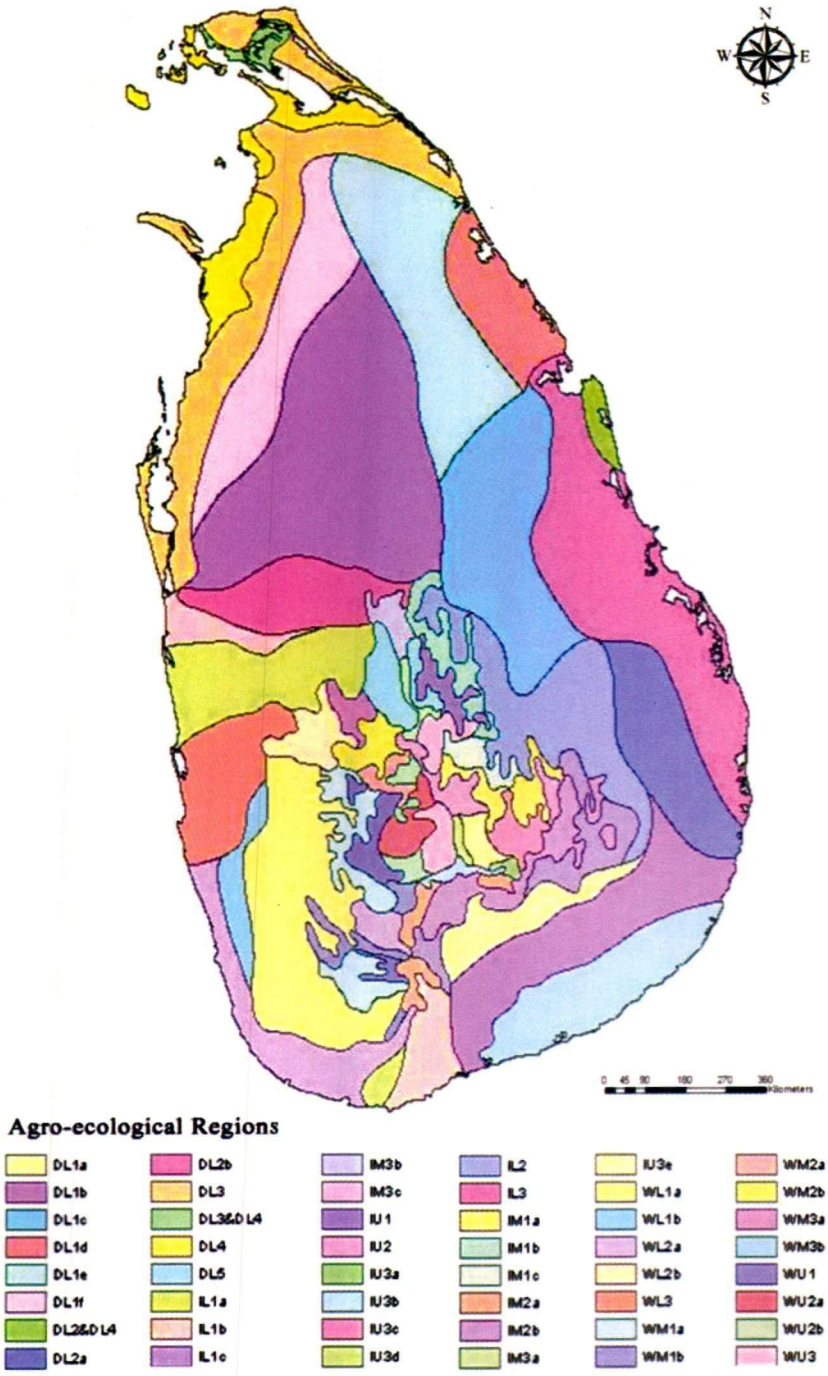


Figure 04: Agro-ecological regions of Sri Lanka 2004[1]

[1] The main distinguishing characteristics of each agro-ecological region are denoted by a 4-character code consisting of letters and a number. Three major climatic zones are indicated by the first upper case letter of

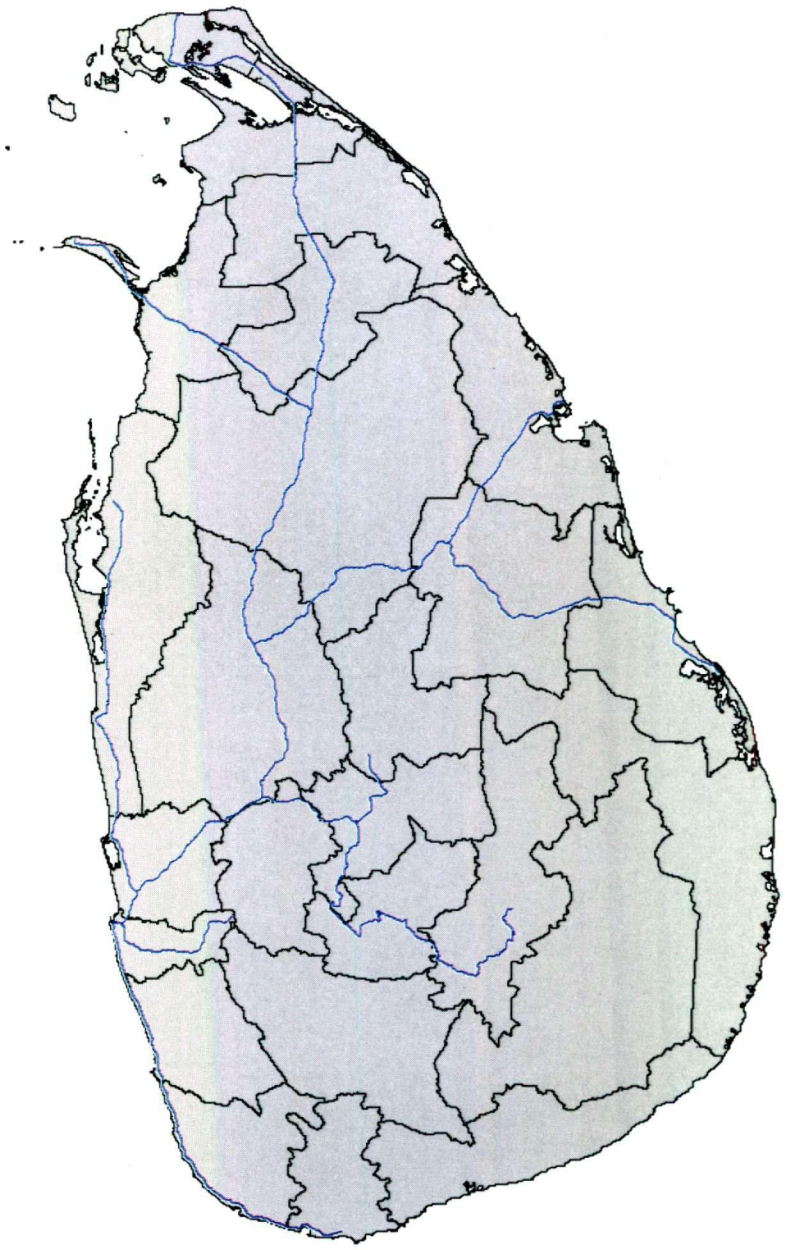


Figure 05: Railroad map of Sri Lanka

the code (W, I and D). The second upper case letter of the code (L, M and U) denotes three categories of elevation. The numerical character in the third place of the code represents a more detailed moisture regime (rainfall and evaporation combined) with a degree of wetness on the scale of 1 to 5 where 1 being the most favorable. The lower case letter in the fourth place indicates a sub-region as determined by rainfall distribution and other physical environmental factors where degree of wetness decreases a > f.

The number of slaughtered animals, egg production and animal population were calculated per 1,000 of human population. The direction of all the crop and livestock production variables was changed by subtracting from the highest value due to the presence of a negative relationship of these variables with food insecurity.

In the case of the variable related to availability of roads, only grade A and grade B roads were used, and both road lengths and railroad lengths were converted into density by dividing the length values obtained by the area of the district. Accordingly, the final figures are shown as kilometers of road length per square kilometer of area.

Average monthly household income, average monthly household expenditure and the food ratio that shows the status of the proportion of expenditure for the food items in terms of total expenditure were considered as having a negative relationship with food insecurity. Colombo district shows the highest values of income and expenditure while the people in Hambantota district spend the highest proportion of their spending for purchasing food items.

All considered health and nutrition data were taken as the percentage or as the rate for population of 1,000 or 10,000. Those variables show positive relationships with food insecurity except the percentage of households with safe drinking water. Accordingly, the values for availability of safe drinking water for each district were subtracted by the highest value which was shown in Colombo district.

Other related variables show both positive and negative relationships and if the relationship is negative they were converted into opposite direction. All the data in this category were presented as percentage or the rate as in health related data.

2.3 Data Analysis

SAS software was used to analyze the collected data. Factor analysis was employed for the reduction of dimensionality of the large number of variables selected for the study.

2.3.1 Application of Factor Analysis on the Reduction of Dimensionality

The factor analysis is a dimension-reduction technique in multivariate statistical analysis resulting in linear combinations of a set of variables, which are uncorrelated with each other so that the first few components explain most of the variations of the original set of variables. Each observed variable (y) can be expressed as a weighted composite of a set of latent variables (f's) such that:

$$y_i = a_{i1} f_1 + a_{i2} f_2 + \ldots + a_{ik} f_k + e_i$$

where y_i is the i^{th} observed variable on the factors, and e_i is the residual of y_i on the factors. Given the assumption that the residuals are uncorrelated across the observed variables,

the correlations among the observed variables are accounted for by the factors (SAS library, online).

The eigen values were extracted when the value is greater than one. The factor loadings were extracted where the score (numerical value) was greater than 0.5. These loadings were assumed to be representing the factors considered in each occasion.

2.3.2 Calculation of Food Insecurity and Vulnerability Index for Separate Categories

Vulnerability indices were calculated for three separate categories, namely food availability based on production, food accessibility and affordability, and other related variables. A food insecurity index was computed for the category of the health and nutritional status of people.

Loadings of factors which have Eigen values greater than one were used to create an index for each category and Eigen values were used as the corresponding weights. Proportional contribution of each factor (a_i) was weighed using Eigen values as given in Equation 02. The vulnerability index of each category for each district was derived as the weight of Eigen value that comes from Equation 02 was imported into the summation of the values coming from the multiplication of actual value of the variable by the relevant factor loading as in Equation 03. This calculation used highly affected variables only according to the factor loadings of each factor. It means that the factors with factor loading greater than 0.5 were taken.

$$a_i = \frac{\lambda_i}{\sum \lambda} \quad \text{(Equation 02)}$$

a_i = Weight of the i^{th} Factor
λ_i = Eigen value of i^{th} Factor
$\sum\lambda$ = Summation of Eigen values for all factors

Vulnerability Index for District = $\sum a_i \sum (X_j * F_{ij})$ Equation 03)

a_i = Weight of the i^{th} Factor
X_j = Actual Value of j^{th} Variable of the Category
F_{ij} = i^{th} Factor Loading of j^{th} Variable

2.3.3 Calculation of Overall or Pooled Food Insecurity and Vulnerability Index

Calculated food insecurity and vulnerability indices through the above relationships (Equation 02 & 03) for the four categories considered were ranked into five groups or classes according to either natural break or equal interval criterion. It means highest food

insecure district got the highest value and accordingly lower food insecure districts got lower ranks. Subsequently, using SAS software, the ranks for separate categories were analyzed for factors further. The overall vulnerability index for each district was calculated using the output of factor analysis as shown in Equations 02 and 04.

Overall Food Insecurity and Vulnerability Index = $\sum a_i \sum (X_j * F_{ij} * p)$ (Equation 04)

a_i = Weight of the i^{th} Factor
X_j = Rank Value of j^{th} Category of the District
F_{ij} = i^{th} Factor Loading of j^{th} Rank Value of Category
P = Constant for Separate Categories

Weight for Food Availability	0.3
Weight for Food Accessibility & Affordability	0.3
Weight for Health and Nutritional Status	0.2
Weight for Other Related Variables	0.2

Food insecurity and vulnerability indices of four individual categories and an overall index were mapped using ArcGIS and a digitized district map of Sri Lanka was used as the spatial demarcation for the districts in this study. Maps indicating vulnerability and food insecurity for each category including the overall index were prepared using the calculated values of vulnerability index for all 17 districts. Two separate maps were prepared for each index according to two classification criteria in ArcGIS: (i) Natural Break Classification and (ii) Equal Interval Classification.

In Natural Break Classification, classes are based on natural groupings inherent in the data. The classification algorithm identifies break points by determining class breaks which best group similar values and maximizes the difference between classes. In statistical terms, Jenkins Natural Break Classification determines the class ranges depending on the number of classes defined by minimizing the sum of the squared differences between an actual value and the mean of its assigned range in each class.

Equal Interval Classification divides the range of attribute values into equal sized sub-ranges by evaluating the lowest and highest values in data distribution. It allows users to specify the number of intervals. According to the values of food insecurity and vulnerability indices, five classes were identified as given below.

- Critically Food Insecure or Vulnerable Area
- Food Insecure or Vulnerable Area
- Moderately Food Insecure or Vulnerable Area
- Less Food Insecure or Vulnerable Area
- Least Food Insecure or Vulnerable Area

Finally, the maps on each theme and each classification criterion were compared. Variables which gave the highest contribution to vulnerability were mapped using bar charts to highlight the importance of these variables in policy interventions.

2.3.4 Estimation of Food Insecurity and Vulnerability Status in Monaragala District

Spatial units for analysis of Monaragala data were Divisional Secretariat divisions and the same methodology was adopted as in the case of district level analysis. Table 03 shows the variables which were used in DS division level analysis according to the different categories.

Table 03: Main data categories and the variables used in the study for Monaragala district

Category	Variables
Food Availability	Population Number of agriculture holdings Agricultural land extent Annual crop production Paddy production Chena production Scrub production Production in home garden Other crop production Livestock population and production
Food Accessibility and Affordability	Road length of type A road Population below poverty level Head count index
Health and Nutritional Status	Live birth rate (per 1000 people) Maternal death rate (per 10000 live births) Infant mortality rate (per 1000 live births) Rate of low birth weight infant (per 1000 people) Percentage of people with safe drinking water Food poisoning
Other Related Variables	Number of hospitals (per 1000 people) Number of medical officers (per 1000 people) Unemployment % Number of schools (per 1000 people) Percentage of people attending to pre schools (age < 5 years) Percentage of people who were not attending to schools Economically active population Percentage of population work in agriculture sector Households with permanent housing units % Households with permanent floor material % Households with permanent wall material % Households with permanent roofing material % Percentage of housing units lighting by electricity Households with using convenient fuel % (Gas/ Electricity) Percentage of housing units with toilets

RESULTS AND DISCUSSION

Food insecurity distribution at district level for the whole country and at DS division level for the Monaragala district were mapped separately according to the four different categories and also according to the two different classification criteria.

3.1 Food Insecurity and Vulnerability Distribution Based on Districts

These maps were developed to show the food insecurity and vulnerability distribution in the country according to the different categories of variables as well as based on different classification criteria.

3.1.1 Vulnerability Index for Food Availability Based on Food Production at District Level

The vulnerability index derived for food availability based on food production was developed by using the variables related to human population, agriculture and livestock data and rainfall data for each district according to the results of the factor analysis. However, it is noted that the index would only be meaningful only if the districts are closed food economies and the production is available for the district before any marketing of production into other districts is undertaken. Further, this index would rather indicate the degree of self sufficiency. A consumption side approach through the calculation of actual calorie values of food intake at household level will be required to assess the overall food availability.

Factor analysis gives four factors in which Eigen values are greater than one. The proportions of those Eigen values are 32.5%, 22.1%, 15.0% and 7.8%, respectively, for the factors one to four. It means that factor one gives the weight of about one-third for the derived vulnerable index based on variables related to food availability based on food production.

The variables contributed at different levels to different factors provide the direction of impact to the vulnerability index based on the associated positive or negative sign. Table 04 shows the factor loadings of thirteen variables and accordingly, total annual rainfall, animal population, number of agriculture holdings, and vegetable production give greater weights for the factors one to four, respectively. Other than the rainfall, population density, cereal production, especially paddy production and the variable on other crop production and milk production provide a greater stimulation for the factor one which makes the highest contribution to the vulnerability index.

Table 04: Factor loadings of variables with higher contributions in the category of food availability based on food production

Variables	Values of 1st Factor	Values of 2nd Factor	Values of 3rd Factor	Values of 4th Factor
Population Density	0.69474	-0.16531	0.40914	0.34968
Number of Agriculture Holdings	0.52691	0.1218	0.79826	-0.10441
Paddy Production	0.56507	0.05558	-0.00925	-0.23042
Vegetable Production	0.47686	-0.59375	-0.41254	0.41579
Other Cereal Production	0.698	-0.27263	0.05842	-0.35013
Fruit Crop Production	-0.04563	-0.37415	0.69803	0.2593
Other Crop Production	0.68779	-0.40888	0.09326	-0.03535
Milk Production	0.59247	-0.28613	-0.53046	0.39041
Egg Production	0.01611	0.83958	0.15871	0.40617
Number of Animal Slaughtered	0.22413	0.61503	-0.37068	-0.10566
Animal Population	0.31894	0.87466	0.06044	0.28431
Total Annual Rainfall	-0.87643	-0.31731	0.13206	0.17474
Modified Fournier Index	0.82984	0.26261	-0.10207	-0.15322

Figures 06 and 07 show the vulnerability distribution based on the availability of food based on food production for the selected districts under the classification methods of natural breaks and equal interval, respectively.

The map represented using natural break classification method for spatial distribution of food insecurity due to food availability based on production shows that Anuradhapura, Polonnaruwa, Kurunegala, and Puttalam districts are categorized under the least vulnerable districts. Matale, Monaragala, and Hambantota districts belong to the less vulnerable class. According to this classification, Badulla and Kandy districts fit into the moderately vulnerable area. Gampaha, Kalutara, Galle, Matara, Kegalle, Ratnapura and Nuwara Eliya districts show high vulnerability except Colombo district which is categorized as a critically vulnerable area as the food production status of Colombo district is very poor.

Figure 07 shows the map of food insecurity derived from the availability of food based on food production, classified using the equal interval classification. It describes all districts under five classes. Similar to the map which classified using natural breaks, Anuradhapura, Polonnaruwa, Kurunegala and Puttalam districts are categorized under the least vulnerable area. In addition to these districts, Monaragala and Hambantota districts are also categorized into the same class under the equal interval classification. Matale and Badulla districts are categorized under the less vulnerable class. Gampaha, Kalutara, Matara, Kandy, Nuwara Eliya, Kegalle, and Ratnapura districts are categorized in the moderately vulnerable class which is more related to the high vulnerable class in the natural break classification.

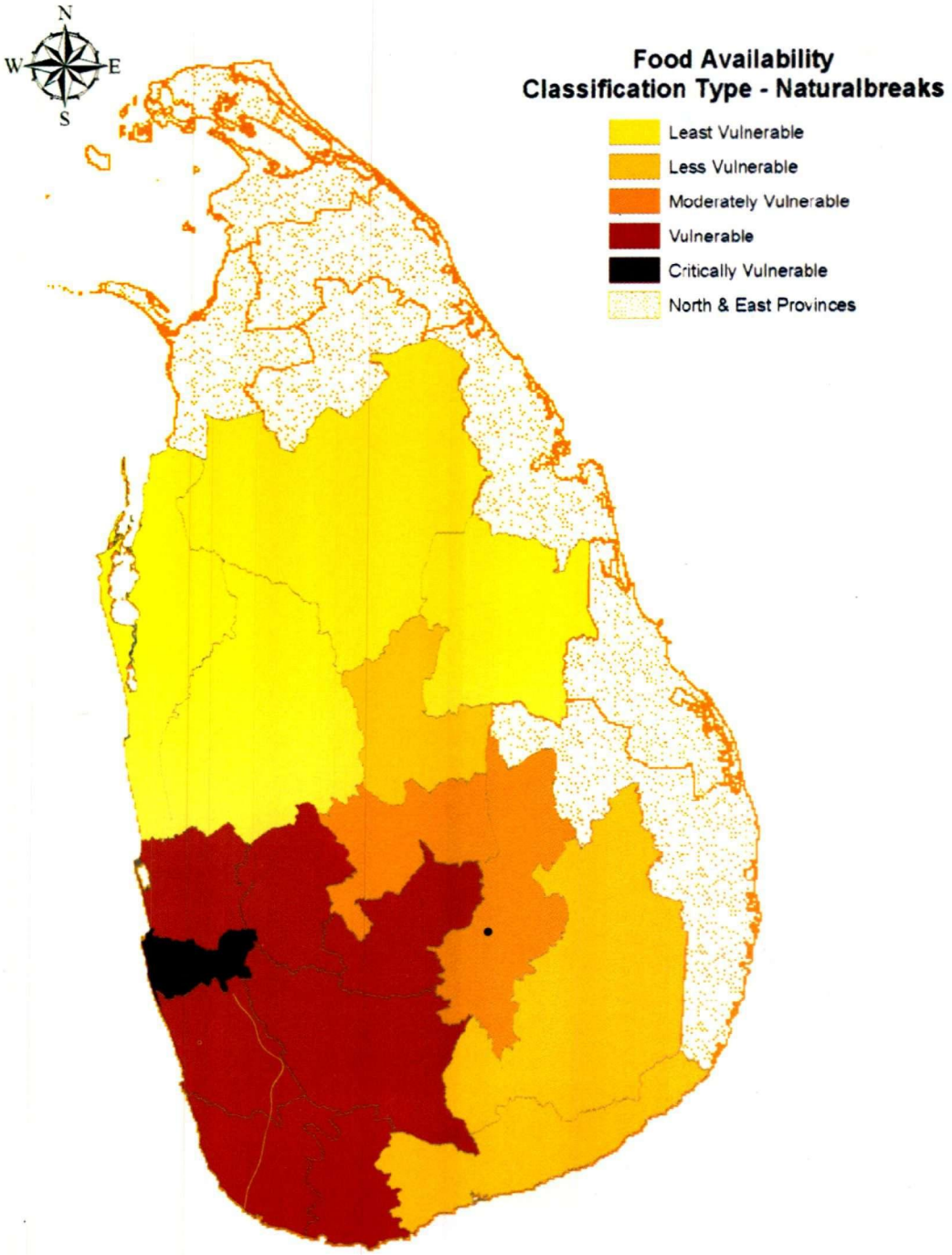


Figure 06: Relative vulnerability in Sri Lanka based on food availability under the natural break classification

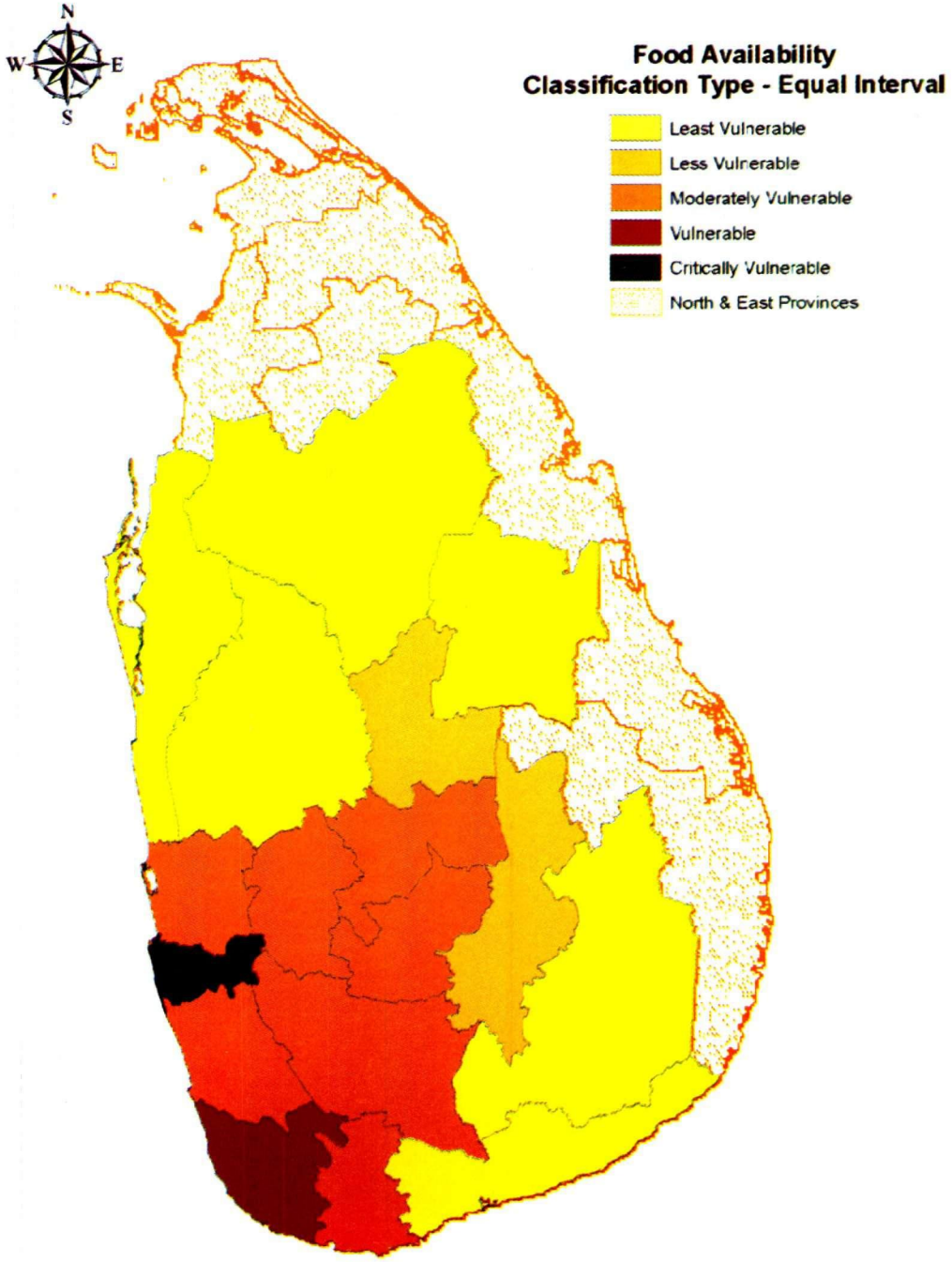


Figure 07: Relative vulnerability in Sri Lanka derived from food availability based on food production under the equal interval classification

According to the equal interval classification method, there is only Galle district classified under the vulnerable class because there is a considerable difference in the

values of the vulnerable index between the critically vulnerable group and the moderately vulnerable group. The Colombo district belongs to the critically vulnerable class in both classification methods. However, as food imports and food production elsewhere in the country end up in the markets in Colombo, true insecurity and vulnerability lie on the purchasing power of the people. The maps with the natural break and equal interval classification methods show clear differences among them. However, both maps have the same values for the vulnerability index for each district. Table 05 shows the summary of the vulnerable groups and the main differences. There is only one district falling into the 'vulnerable' class according to the equal interval method, while more districts are classified into the group under the natural breaks classification. Districts that belong to the vulnerable class in the natural break classification map have moved into the moderately vulnerable class in the equal interval classification. This suggests that the pictorial information from maps needs to be interpreted with caution.

Table 05: Levels of vulnerability of districts due to food availability based on food production under the classification types of natural break and equal interval

Vulnerability Class	**Districts based on Natural Break Classification**	**Districts based on Equal Interval Classification**
Least Vulnerable	Anuradhapura, Polonnaruwa, Kurunegala, Puttalam	Anuradhapura, Polonnaruwa, Kurunegala, Puttalam, Monaragala, Hambantota
Less Vulnerable	Matale, Monaragala, Hambantota	Matale, Badulla
Moderately Vulnerable	Kandy, Badulla	Gampaha, Kalutara, Matara, Kandy, Kegalle, Ratnapura, Nuwara Eliya
Vulnerable	Gampaha, Kalutara, Galle, Matara, Kegalle, Ratnapura, Nuwara Eliya	Galle
Critically Vulnerable	Colombo	Colombo

It is obvious here that the categorization of districts into vulnerable classes can be different under different classification methodologies. It is also understood that other classification methodologies such as defined intervals and quantiles may present slightly different vulnerability categories for each district. The vulnerability class of each district depends on the number of classes identified, type of classification methodology, and any dataset used for the normalization of the classified product. Therefore, objective comparisons of the map with similar map products do not result in any meaningful outcome. However, it should be emphasized that the addition of a few more variables into the analysis should not result in a much different output as there is a large number of variables used in the analysis to capture most of the contributing factors for vulnerability due to food availability based on food production. The results would be quite different from the presented map if other aspects of food availability are considered. Food availability based on production would only indicate the degree of self-sufficiency within a single district, which would misinterpret the prevailing actual situation with considerable quantity of food imports. If a food accessibility based approach is adopted

to represent food availability, the vulnerability status of most of the districts would show up differently. The Colombo district would be a classic example for this.

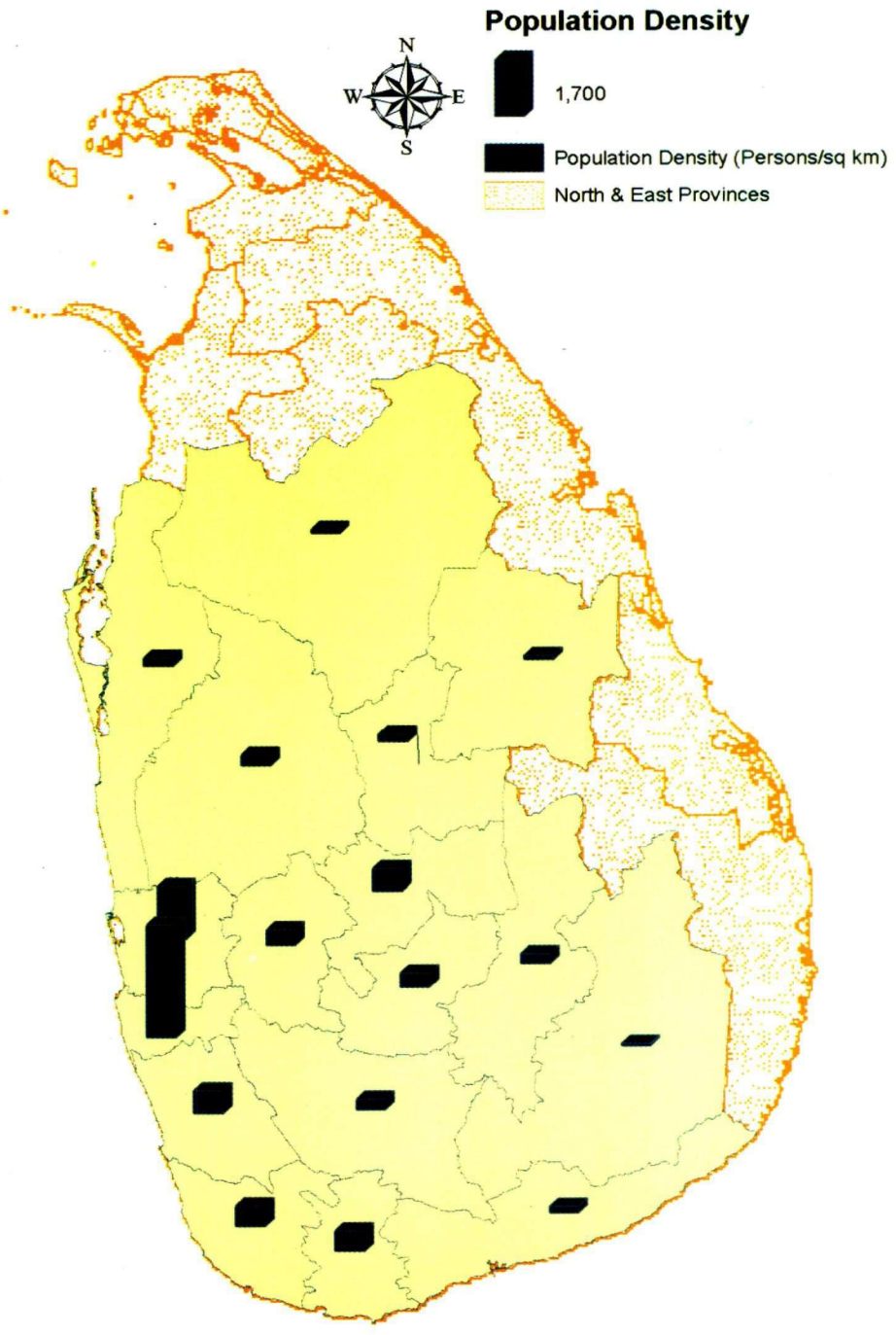


Figure 08: Population density of Sri Lanka at district level

According to the results of the factor analysis, the contributions of some of the variables to the vulnerable index are high such as population density, cereal production and other crops including pulses, spices, oil crop and tuber crop production.

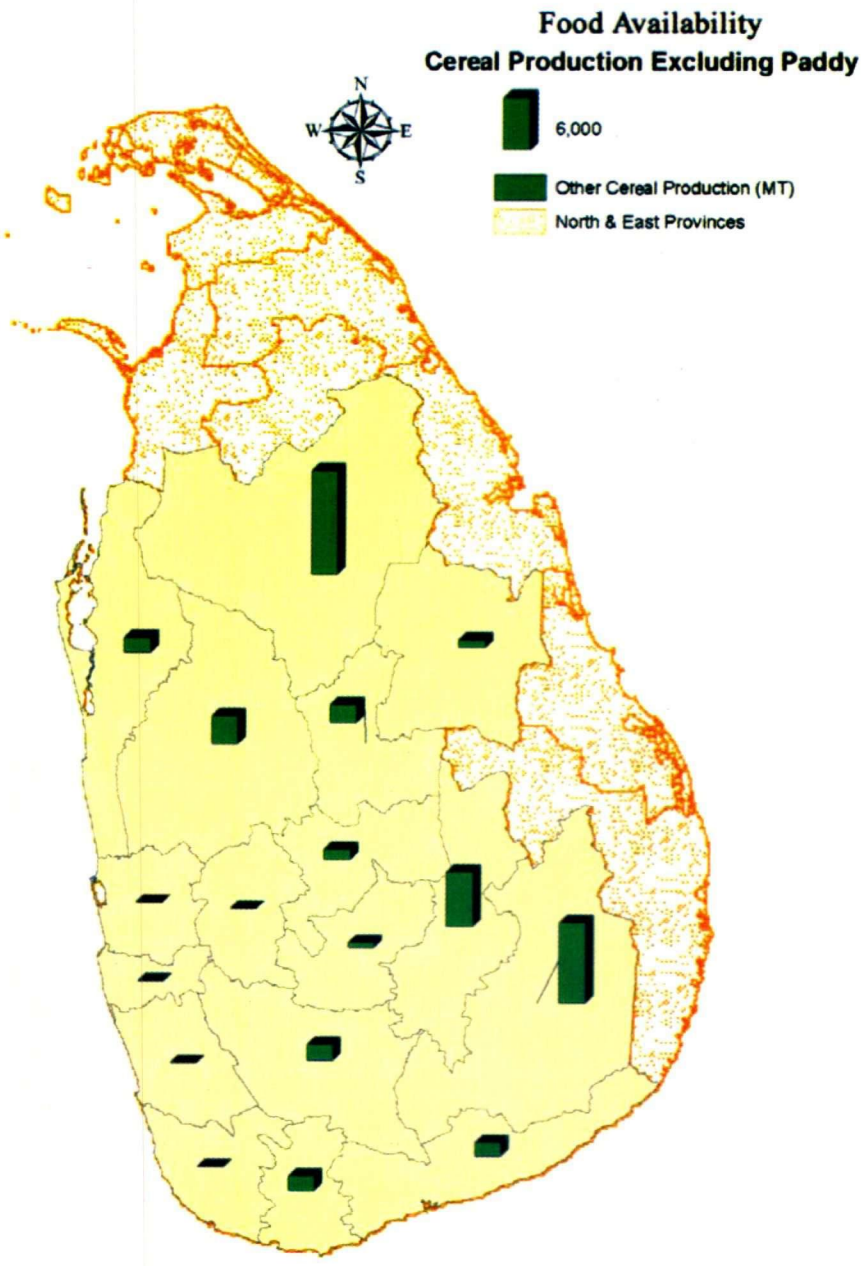


Figure 09: Distribution of annual cereal production excluding paddy in the districts of Sri Lanka

Figure 08 shows the distribution of the population density of each district. According to the map, the population density in Colombo district is more than double of the corresponding value of Gampaha district. Colombo has 3,305 heads per square kilometer, while Gampaha district is inhabited by 1,541 heads per square kilometer. Also the least value of 72 heads per square kilometer is recorded at Monaragala district. The demand for food increases with increasing population. Accordingly, population density is positively correlated with food insecurity. Colombo appears to be in a critical condition of food insecurity, whereas and districts with low population density such as Monaragala, Anuradhapura, Polonnaruwa, Hambantota, Matale, Puttalam, Badulla, and Kurunegala districts (72, 112, 117, 210, 227, 245, 274 and 314 heads per square kilometer, respectively) shows a relatively food secure situation based on the variables in the category of food availability.

Other than the population density, the categorization is also heavily affected by the cereal production of each district and the other crop production which includes pulses, spices, oil crops and tuber crops. Variability of those variables at district level is shown in Figure 09 and Figure 10, respectively. According to those figures, both cereal production and other crop production show high figures in Anuradhapura, Badulla, Monaragala, and Kurunegala districts. In addition, production of spices which is considered as other crops is high in Matale and Ratnapura districts which show the intermediate climatic conditions. Accordingly, those areas show low level of vulnerability with respect to food availability and especially due to the production of the food items. However, most of the spices are exported to foreign markets and local markets elsewhere.

Paddy cultivation is extensively practiced in the districts which are categorized into the low vulnerable classes, especially in Polonnaruwa and Hambantota districts. It gives high contribution to the food security because rice is the staple food of Sri Lankan nationals. Further, paddy production gives a true status of food security as these areas are mainly dominated by subsistence agriculture. In areas where large farms operated by corporations are the major source of production, paddy production does not reflect true food availability for the people as most of the people are paid for labour only.

The extent of agricultural lands and productivity of agriculture are high in the same districts. According to the past figures, animal husbandry is also popular in the low vulnerable areas and especially in Kurunegala and Puttalam districts.

The availability of food does not depend not only on food production in any given district. Most of the food production in the above districts ends up in the markets in Colombo. In addition, food imports play a significant role in the overall food availability status. Further, the quality of the available food needs to be assessed in order to arrive at a proper evaluation of food availability.

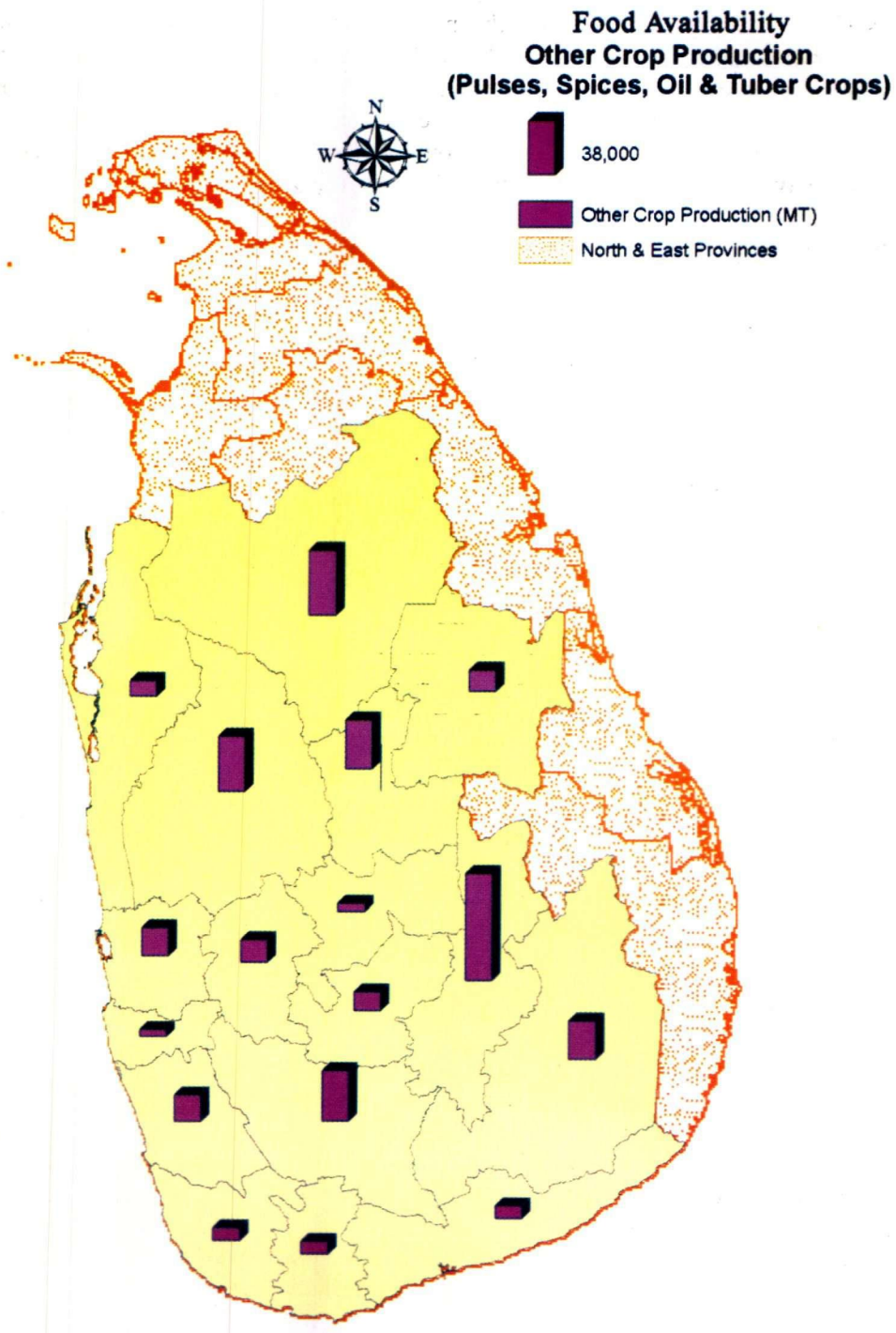


Figure 10: Distribution for annual production of pulses, spices, oil crops, and tuber crops at district level

In this situation, one could question the potential use of a map which is developed considering only food production variables to denote food insecurity. It should be noted that any intervention to combat food insecurity at national level needs substantial improvement in food production and therefore, the identification of food insecure areas would assist in focusing policy influences only to the districts where improvements in production have significant prospects. In such an exercise, ranking of the districts as per the vulnerability status of food availability based on food production would provide more insight in the process of prioritization. Table 06 shows the vulnerability ranking of each district based on food availability derived from food productions statistics.

Table 06: Relative vulnerability of districts ranked based on food availability based on food production

District	Relative Vulnerability Based on Food Production
Anuradhapura	4
Badulla	8
Colombo	17
Galle	16
Gampaha	14
Hambantota	5
Kalutara	15
Kandy	9
Kegalle	13
Kurunegala	1
Matale	7
Matara	12
Monaragala	6
Nuwara Eliya	11
Polonnaruwa	2
Puttalam	3
Ratnapura	10

3.1.2 Vulnerability Index for Food Accessibility and Affordability at District Level

This category includes the variables related to the ability or potential of people to access food, such as road density and the income and expenditure of households. It can be argued that food accessibility is not an important variable where there is a demand for food in an open market economy and there is no barrier for supply of food items because of the relatively well-distributed road network available in the country. Yet, the accessibility of food is considered as an important variable due to the fact that only a few central markets are located in the country and all the food items are transferred through these markets where accessibility plays an important role.

In the factor analysis, it gives only a single factor with Eigen value greater than one, and that factor gives the weight of 80.7 % from the variables. Table 07 shows the values which are given by each variable for this factor. All the variables give values of more

than 0.8 as the factor loadings for the factor one, and it ranges in between 0.83 to 0.95. Accordingly, all the factors strongly contribute to the factor one, and the vulnerability index is calculated using factor loadings of all the variables. It also shows that these variables are highly correlated with each other.

Table 07: Factor loadings of variables in the category of food accessibility and affordability

Variables	**Factor Values**
Type A Road Density	0.82925
Type B Road Density	0.85308
Railway Density	0.93563
Total Household Income	0.94906
Expenditure on Food Items	0.94917
Food Ratio	-0.86486

Figures 11 and 12 show the district level maps which show the food insecurity condition with relation to accessibility and affordability of food under the classification methods of natural break and equal interval, respectively.

The map produced with the natural break classification method classifies Colombo and Gampaha into the least vulnerable class, while Kalutara, Galle, and Kandy districts belong to the less vulnerable class. Most of the districts show the medium condition of vulnerability according to the accessibility and affordability theme. It means that the moderately vulnerable class includes Matara, Kurunegala, Puttalam and Anuradhapura districts while Matale, Nuwara Eliya, Badulla, Monaragala, and Hambantota were classified as vulnerable areas. There are three districts found in the critically vulnerable group including Kegalle, Ratnapura and Polonnaruwa.

According to Figure 12, the equal interval classification method, classifies all districts into four groups. There is no district classified as a moderately vulnerable district. It categorizes only Colombo district as the least vulnerable district, while Gampaha goes under the less vulnerable group. It categorizes Kalutara, Galle, Kandy, and Puttalam into the vulnerable class, and the other districts including Matale, Nuwara Eliya, Matara, Hambantota, Anuradhapura, Polonnaruwa, Kurunegala, Badulla, Monaragala, Kegalle, and Ratnapura, show critically vulnerable condition according to accessibility and affordability.

According to Figures 11 and 12, the same vulnerability index values give different maps for the different classification types. The summary of those classifications (Table 08) shows a clear difference between the natural break classification type and the equal interval classification type. That is to say that the natural break classifies all districts into five groups, while the equal interval method classifies districts into four categories.

Further, in the equal interval classification method, 11 out of 17 districts are classified as critical areas, while the natural break classification divides districts somewhat equally.

These results also demonstrate the sensitivity of vulnerability classes for the classification method.

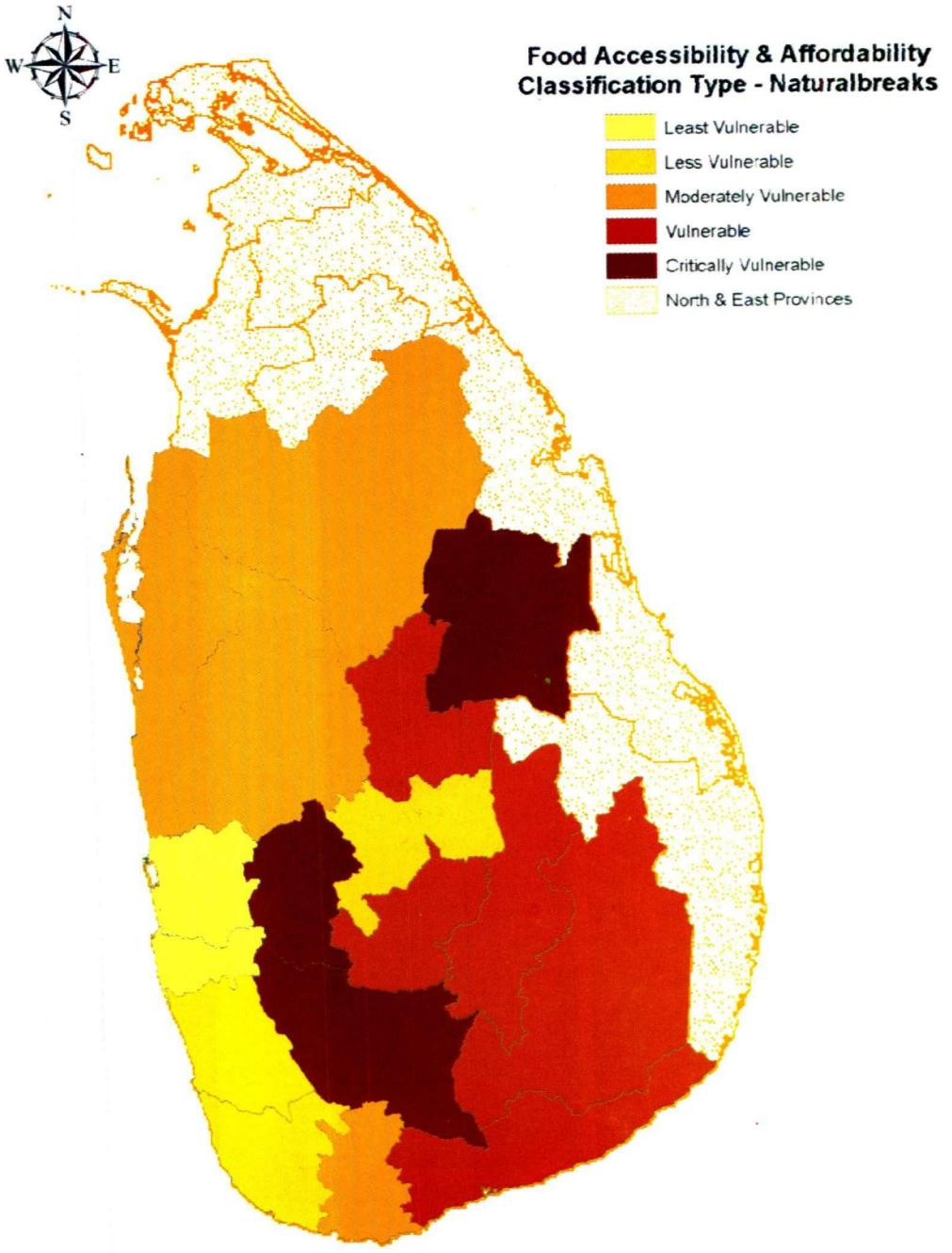


Figure 11: Relative vulnerability in Sri Lanka based on food accessibility and affordability under the natural break classification

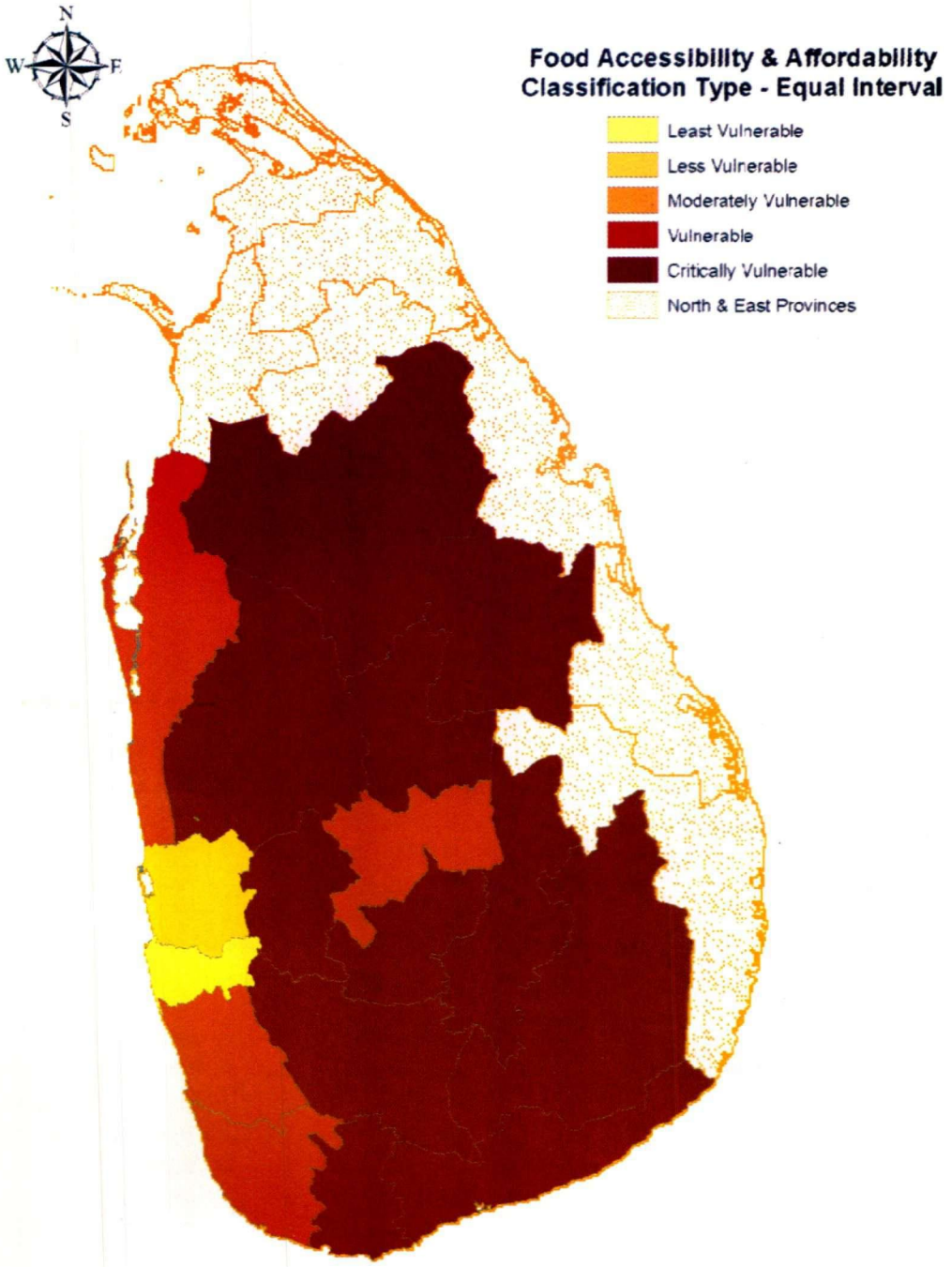


Figure 12: Relative vulnerability in Sri Lanka based on food accessibility and affordability under the equal interval classification

Table 08: Levels of vulnerability of districts based on food accessibility and affordability under the classification types of natural break and equal interval

Vulnerability Class	Districts based on Natural Break Classification	Districts based on Equal Interval Classification
Least Vulnerable	Colombo, Gampaha	Colombo
Less Vulnerable	Kalutara, Galle, Kandy	Gampaha
Moderately Vulnerable	Matara, Kurunegala, Puttalam, Anuradhapura	
Vulnerable	Matale, Nuwara Eliya, Badulla, Monaragala, Hambantota	Kalutara, Galle, Kandy, Puttalam
Critically Vulnerable	Kegalle, Ratnapura, Polonnaruwa	Matale, Nuwara Eliya, Matara, Hambantota, Anuradhapura, Polonnaruwa, Kurunegala, Badulla, Monaragala, Kegalle, Ratnapura

The factor analysis output showed in Table 07 indicates that the highly affected two variables for the factor one are the household income and the household expenditure on food items. The values of these two variables in each district are shown in Figures 13 and 14, respectively.

According to Figure 13, Colombo and Gampaha show a considerable income difference when compared to the other districts. In Sri Lanka most of the large scale business owners and employees with high income levels live in Colombo district, and also most of the economic activities are linked with Colombo district. However, it does not show the actual situation as majority of the people is not in high income categories. The reason for a high income level is due to a few large income earners. Accordingly, the influence at the final district average is negligible from those low income holders. Classification of Colombo into the high income category could make the situation of the poor in Colombo from bad to worse since there would be less public expenditure allocated to Colombo. However, income disparities existing in Colombo should be reflected in the other indicators such as health and nutrition. Further, it should be noted that the district level is not an ideal spatial demarcation for analysis and that some other spatial unit at sub-district level should be the basis for data collection to identify the urban poor in Colombo.

The expenditure on food items which is shown in Figure 14 gives the highest effect on the vulnerable index of this category. The maximum values of 7,800 and 6,749 rupees per household per month are in Colombo and Gampaha districts, respectively. There are the districts classified as low vulnerable areas in both classification methods. Minimum value of 4,569 rupees per household per month is recorded for Badulla district. It means that the range of this expenditure variation is small. People in highly urbanized districts such as Colombo and Gampaha spend more money on food items because people buy most of their food items than producing for their own consumption and also mostly they have an affinity for expensive, luxury foods.

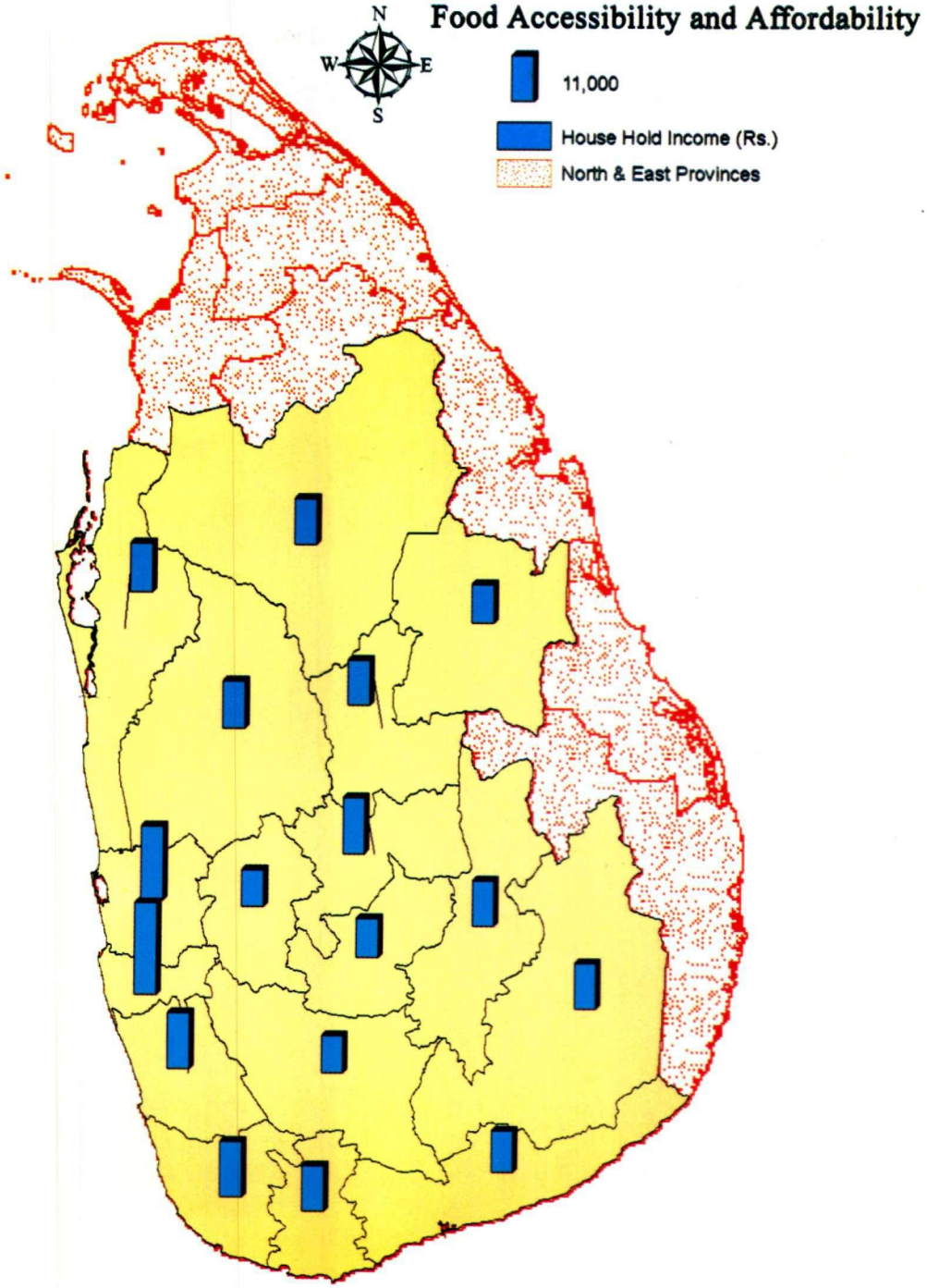


Figure 13: Average household income at district level

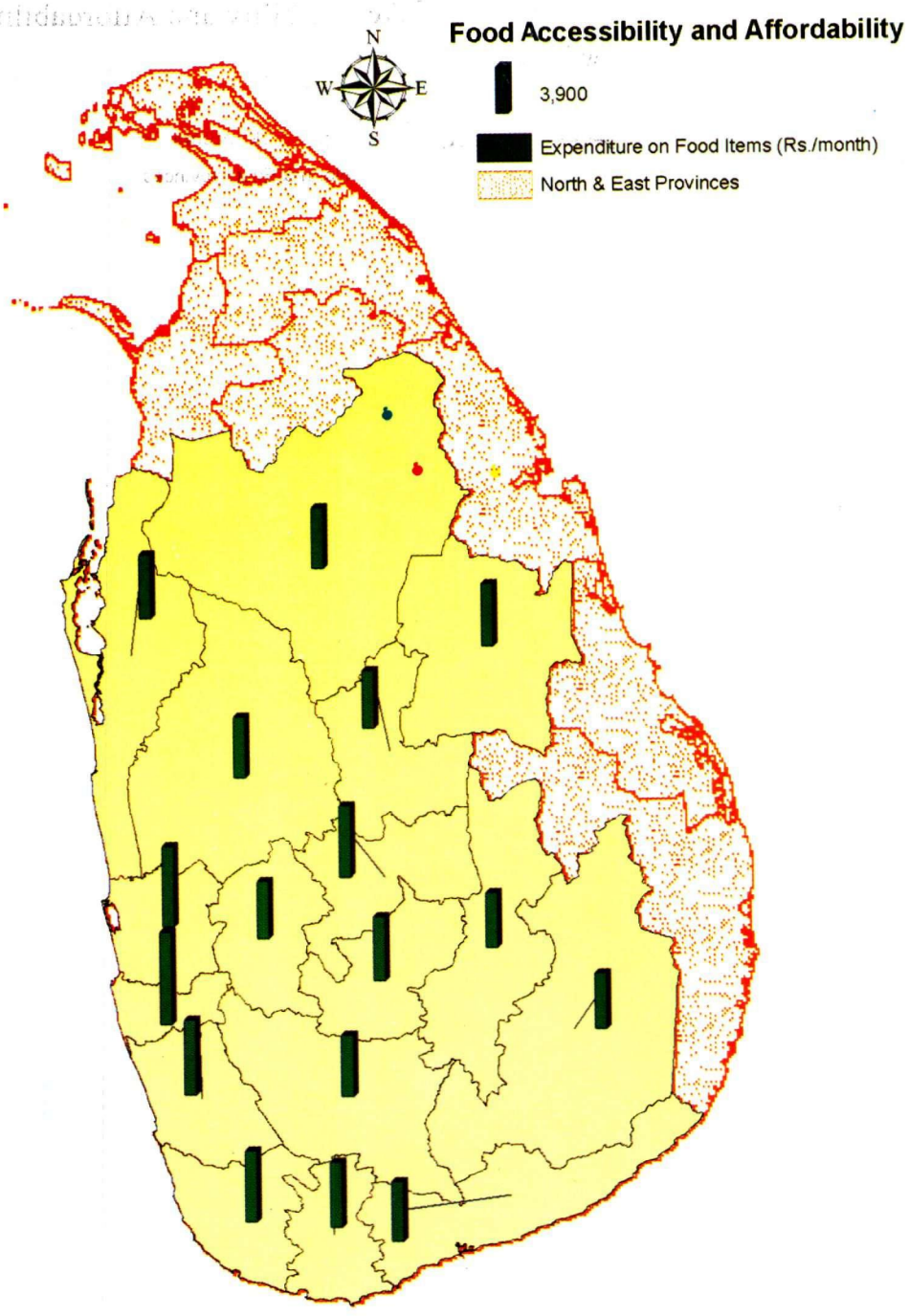


Figure 14: Average household expenditure on food items at district level

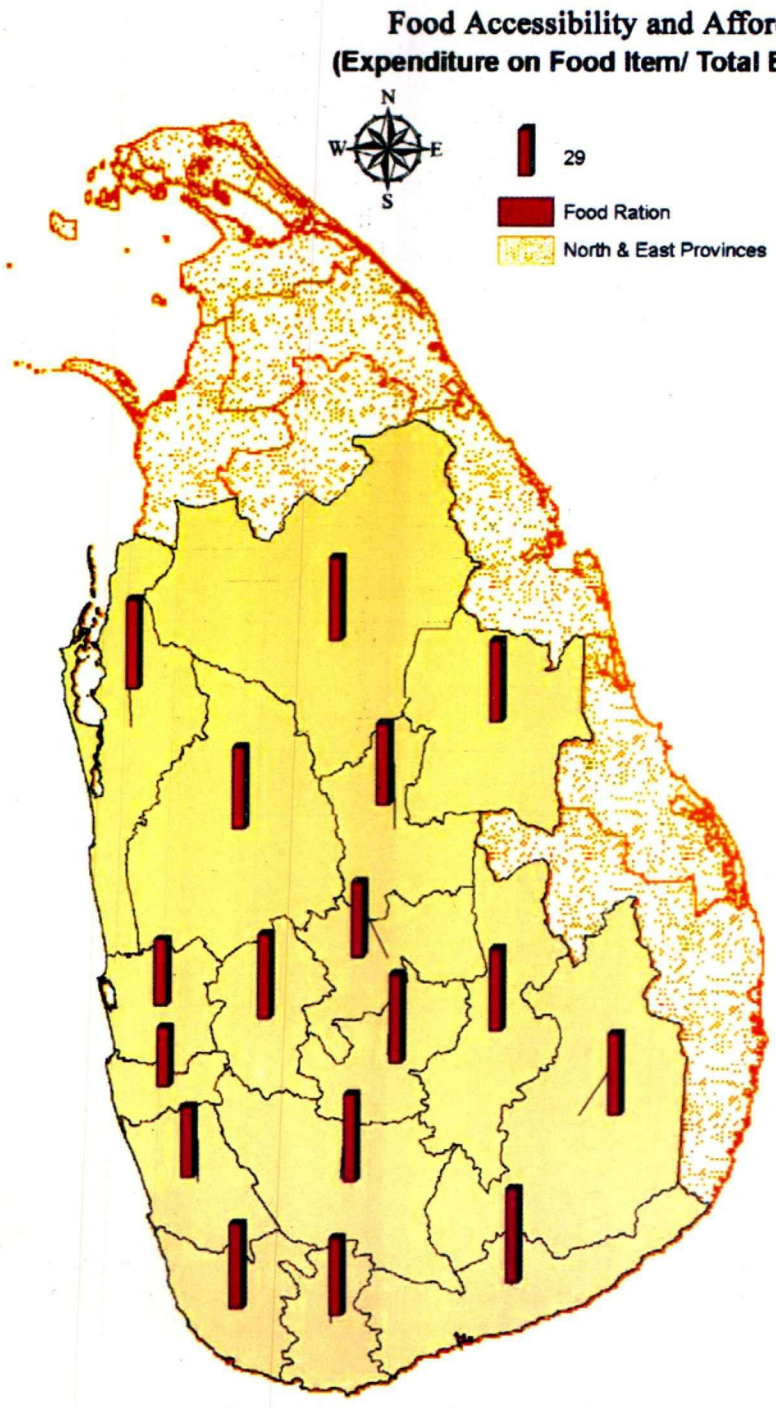


Figure 15: Average food ratio at district level

According to the accessibility and affordability of food, low vulnerable districts such as Colombo and Gampaha spend more money for food items than severely vulnerable districts such as Kegalle, Ratnapura, and Polonnaruwa. But according to the food ratio which is derived as a proportion of expenditure on food items with respect to the total expenditure as shown in Figure 15, all districts show more or less similar figures. It means that the proportion of expenditure for food from total expenditure of people in the country does not have a significant spatial variability, indicating that the disparities arise amongst the high income group in Colombo and Gampaha. Table 09 shows the vulnerability ranking of each district based on food accessibility and affordability.

Table 09: Relative vulnerability of districts ranked based on food accessibility and affordability

District	Relative Vulnerability Based on Food Accessibility and Affordability
Anuradhapura	9
Badulla	12
Colombo	1
Galle	4
Gampaha	2
Hambantota	13
Kalutara	3
Kandy	5
Kegalle	17
Kurunegala	8
Matale	10
Matara	7
Monaragala	11
Nuwara Eliya	14
Polonnaruwa	15
Puttalam	6
Ratnapura	16

3.1.3 Food Insecurity Index for Health and Nutritional Status of the Nation at District Level

Some variables in this category such as malnutrition and nutrient deficiency are directly related to food security reflected in the health and wellness of the people, while some others give indirect relationships such as crude birth rate, crude death rate, etc. According to the factor analysis, health and nutrition related variables give two factors, with Eigen value weight of 58.3 % from the factor one and 15.9 % from the factor two. It means that the weight of the factor one is more than half of the final food insecurity index of health and nutritional status. Also, according to the Table 08 that shows the factor loadings of mostly affected variables for the two factors, the factor one is highly influenced by the variables of percentage of stunted children below 5 years old, percentage of underweight children below 5 years old, percentage of wasted children below 5 years old, and prevalence of diarrhea. Table 10 also shows that the rate of low birth weight infant has

the highest influence on the index. Further, according to the results of the factor analysis, malnutrition variables clearly indicate food insecurity through the health and nutritional status component of the vulnerability index.

Table 10: Factor loadings of highly affecting variables in the category of health and nutritional status

Variable	Values of 1st Factor	Values of 2nd Factor
Live Birth Rate	0.76218	0.49078
Crude Birth Rate	0.80086	0.50405
Crude Death Rate	0.79576	-0.07485
Low Birth Weight Infant	-0.37724	0.81273
Maternal Death Rate	0.5849	0.07143
Safe Drinking Water	-0.55138	0.60326
Prevalence Of Diarrhea	0.83306	-0.1911
Percentage of Stunted Children	0.91884	0.10864
Percentage of Wasted Children	0.90433	-0.11887
Percentage of Underweight Children	0.91202	0.05059

Figures 16 and 17 show the distribution of food insecurity for Sri Lanka except North and East provinces with respect to the health and nutritional status of the nation using the natural break and equal interval classification methods. Both classification types classify Gampaha and Kegalle districts as least food insecure areas. Other than those, Kalutara, Ratnapura, Nuwara Eliya, and Monaragala are also in this class according to the equal interval classification, while those are in the less food insecure class using natural breaks. The less food insecure group in equal intervals is similar to the moderate food insecure class in natural breaks that includes Matale, Matara, and Hambantota. Similarly, the moderate food insecure class in equal interval is same as the food insecure class in natural breaks. Galle, Badulla, Anuradhapura, Polonnaruwa, Kurunegala, and Puttalam districts are classified under this. According to the natural breaks method, Colombo and Kandy show a critical condition, while Kandy moves to the food insecure class according to the equal interval classification due to the health and nutritional status of the population.

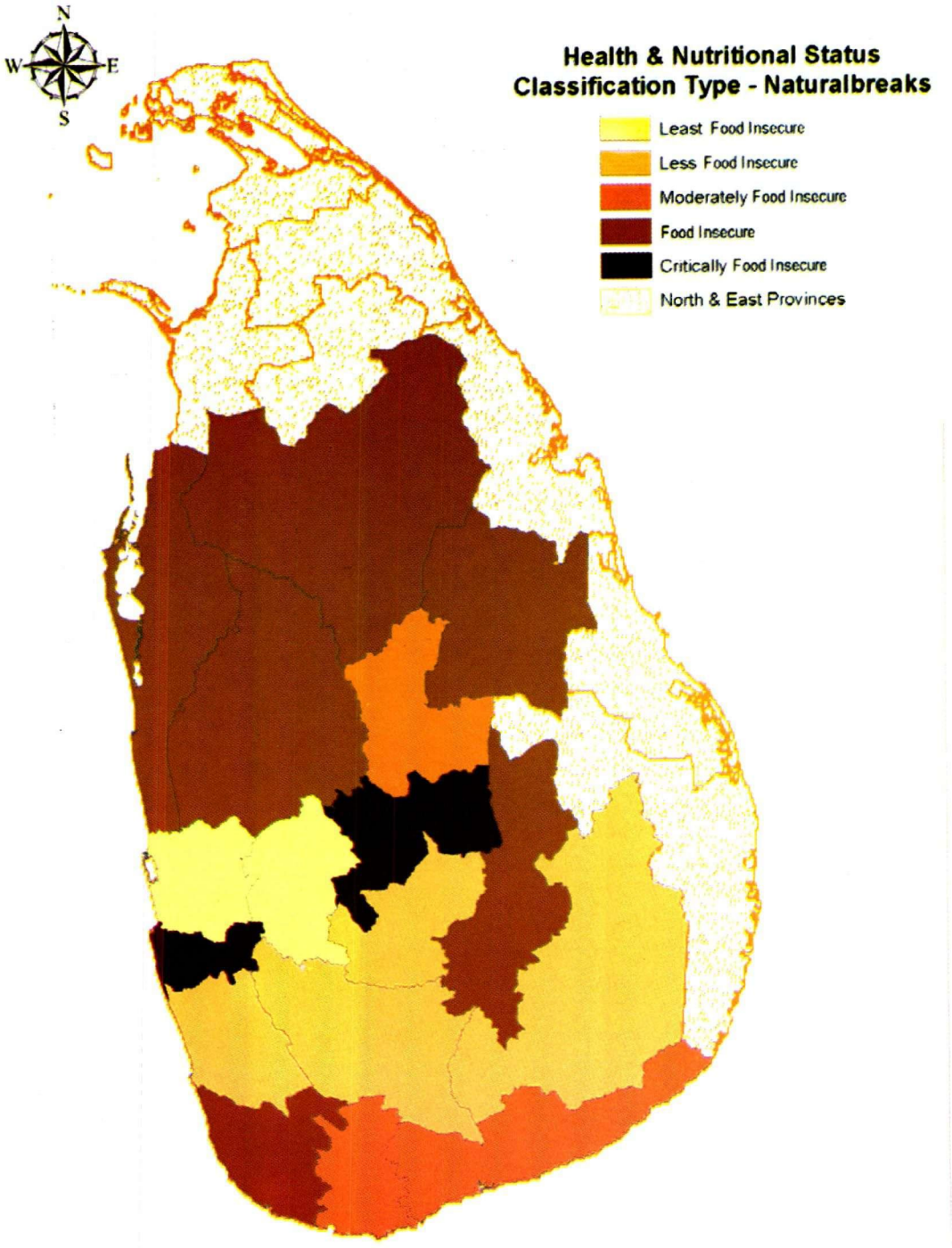


Figure 16: Relative food insecurity in Sri Lanka based on the health and nutritional status under the natural breaks classification

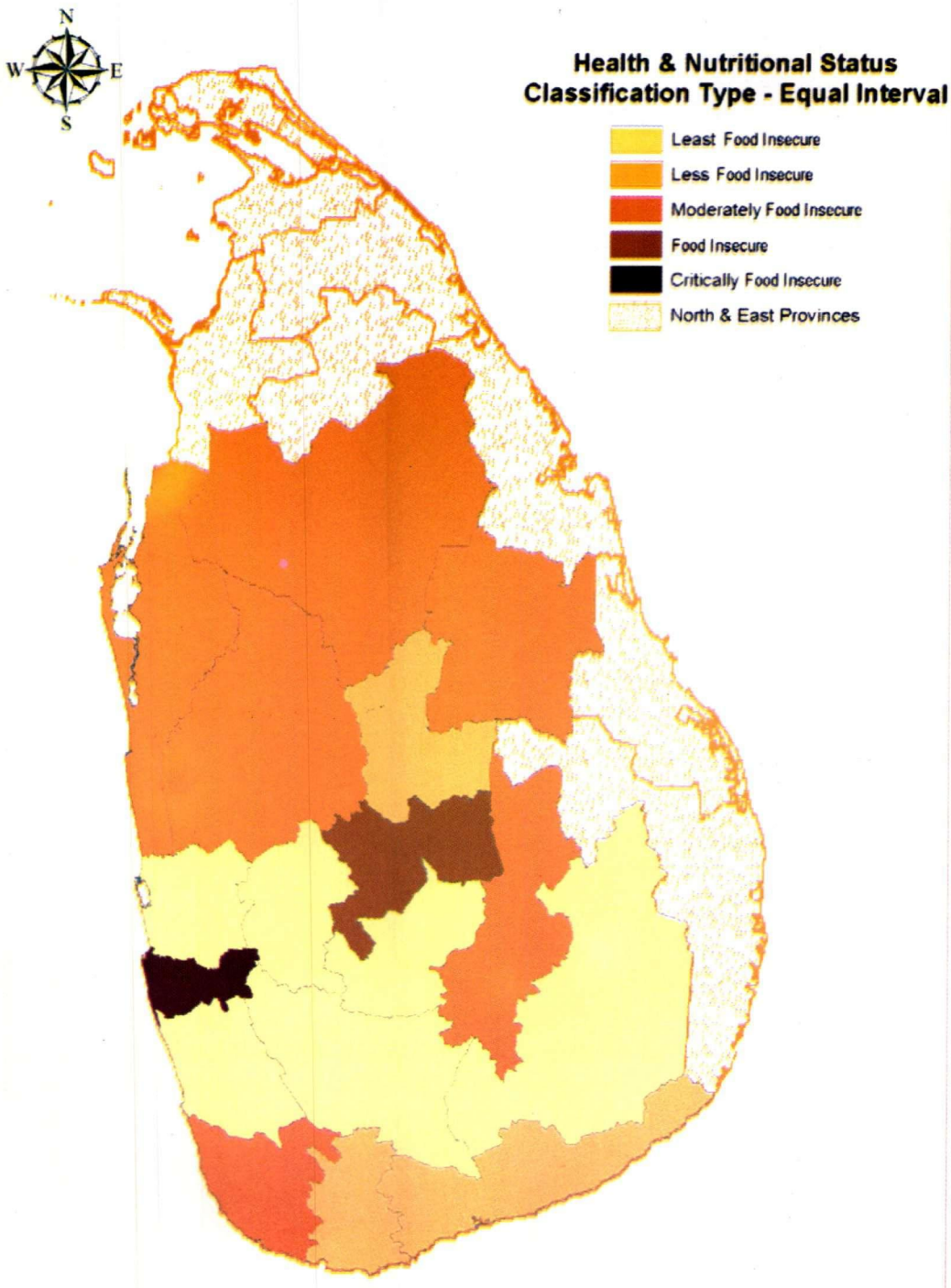


Figure 17: Relative food insecurity distribution in Sri Lanka based on the health and nutritional status under the equal interval classification

Table 11 shows the summary of details indicated in Figures 16 and 17. According to these figures, classification moves towards the more food secure direction in the equal interval classification with respect to the natural breaks classification. Further, most of the districts are categorized under the middle level food insecurity classes, namely moderately food insecure and less food insecure levels.

Table 11: Levels of food insecurity of districts due to the health and nutritional status of people under the classification types of natural break and equal interval

Food Insecurity Class	**Natural Break**	**Equal Interval**
Least Food Insecure	Gampaha, Kegalle	Gampaha, Kalutara, Kegalle, Ratnapura, Nuwara Eliya, Monaragala
Less Food Insecure	Kalutara, Ratnapura, Nuwara Eliya, Monaragala	Matale, Matara, Hambantota
Moderately Food Insecure	Matara, Hambantota, Matale	Galle, Badulla, Puttalam, Kurunegala, Anuradhapura, Polonnaruwa
Food Insecure	Galle, Anuradhapura, Polonnaruwa, Badulla, Kurunegala, Puttalam	Kandy
Critically Food Insecure	Colombo, Kandy	Colombo

This is one of the very important categories in terms of food security that reveals clearly the nutritious level of food that people consume. According to the factor analysis output which was shown in Table 10, mostly contributing factors for this category are percentage of stunted children below 5 years old, percentage of underweight children below 5 years old, percentage of wasted children below 5 years old and prevalence of diarrhea. The statistics of those factors are shown in Figures 18, 19, 20 and 21, respectively.

According to Figure 18 that shows the percentage of stunted children by district, Colombo, Kandy, and Galle districts give the very high figures, while Gampaha, Kalutara, Matale, and Kegalle show low figures.

Figure 19 shows the percentage of underweight children at district level with Gampaha, Kalutara, Matale, and Kegalle districts showing low values similar to what is shown in Figure 18.

The district level percentage of wasted children under 5 years old is shown in Figure 20. The least vulnerable districts in both classification types are Gampaha and Kalutara districts as they show the lowest values.

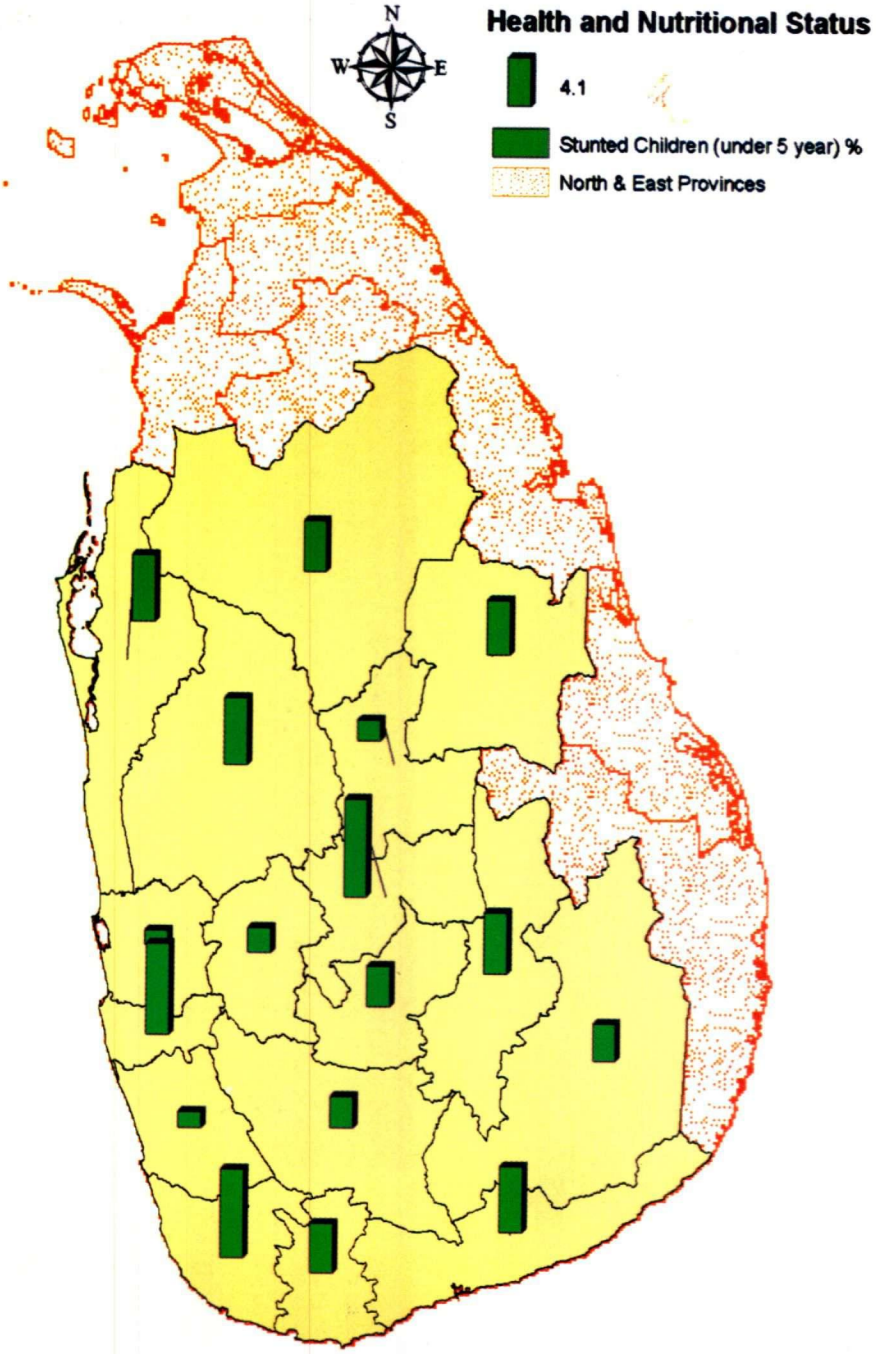


Figure 18: Percentage of stunted children under 5 years old at district level

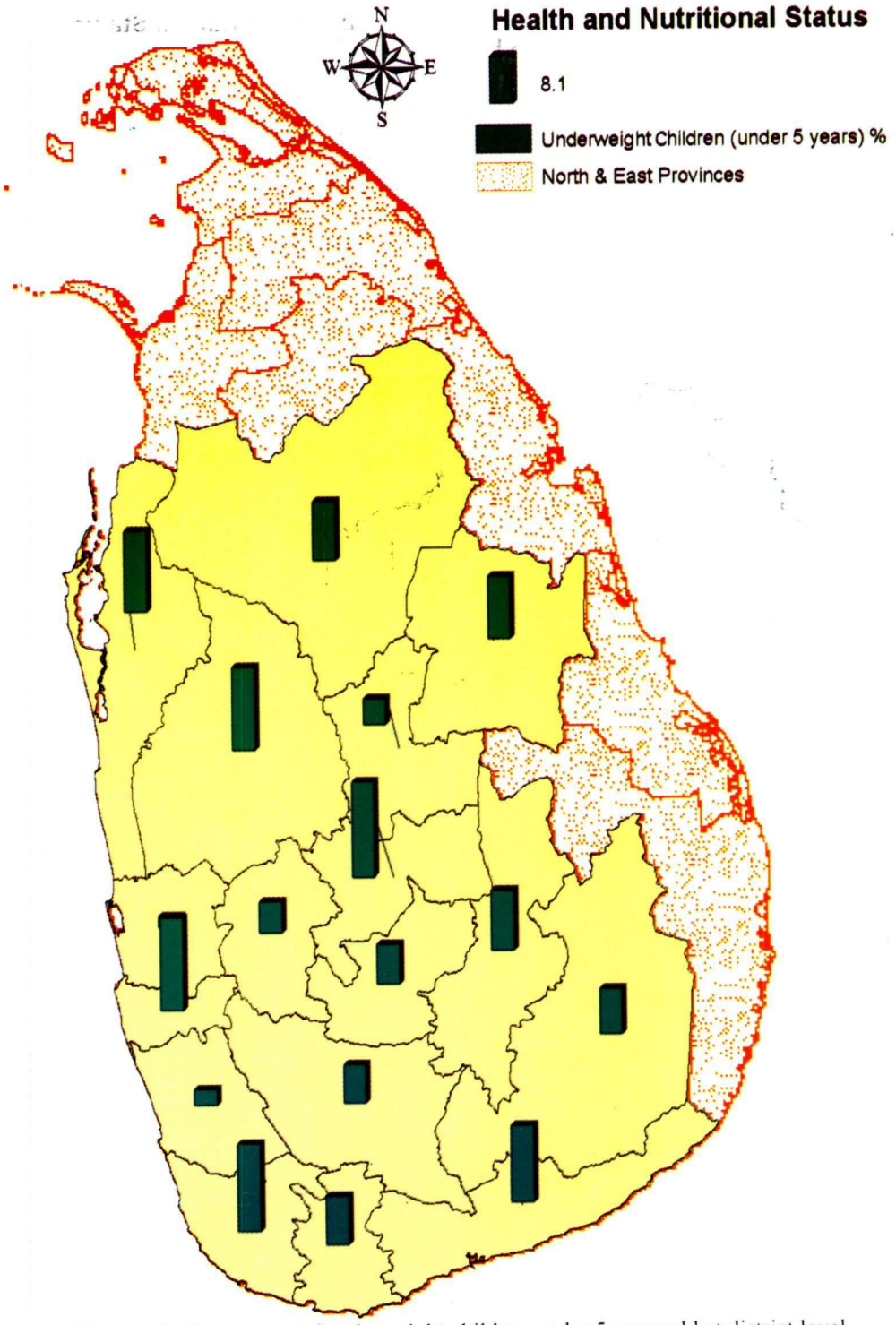


Figure 19: Percentage of underweight children under 5 years old at district level

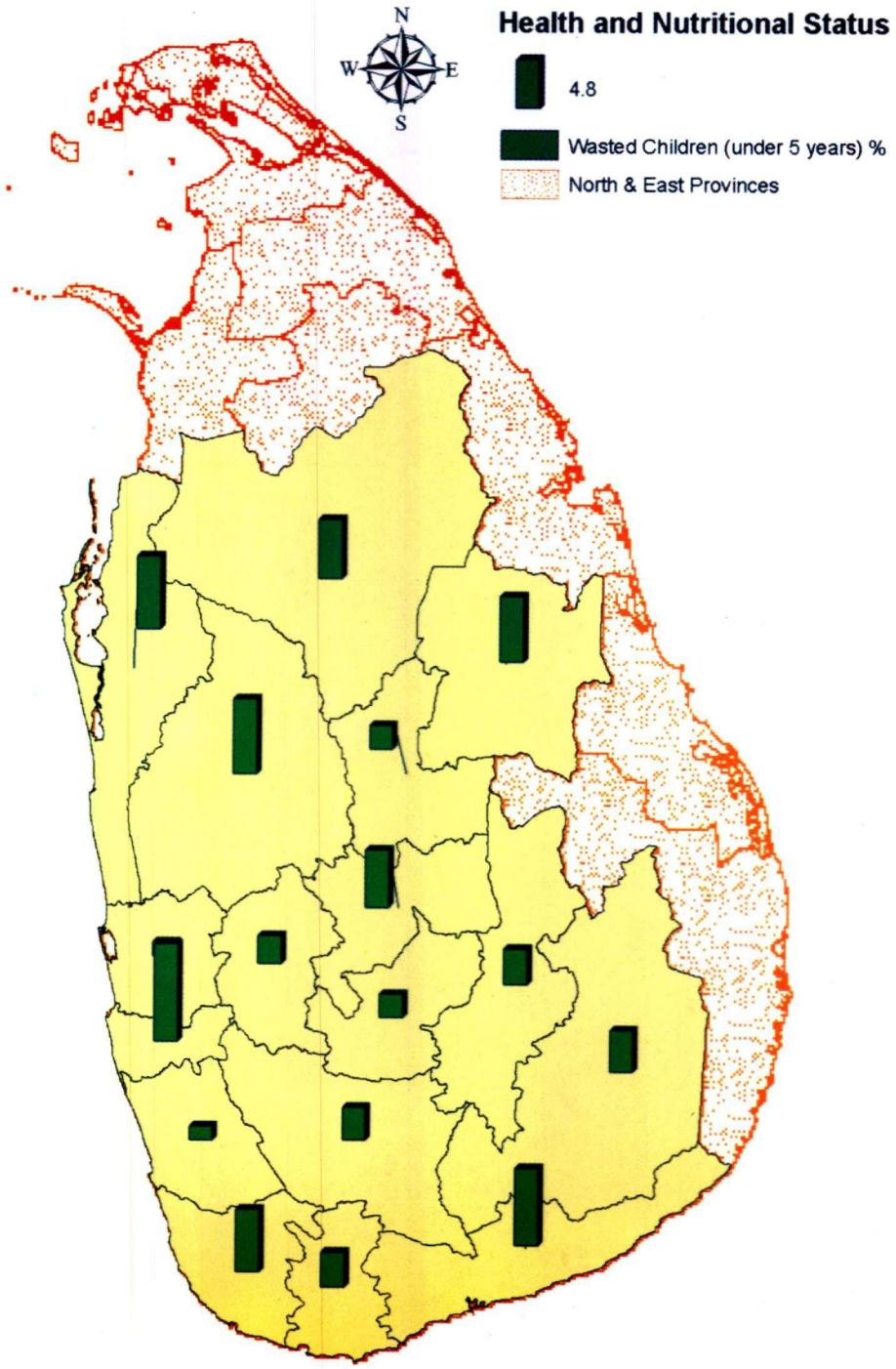


Figure 20: Percentage of wasted children under 5 years old at district level

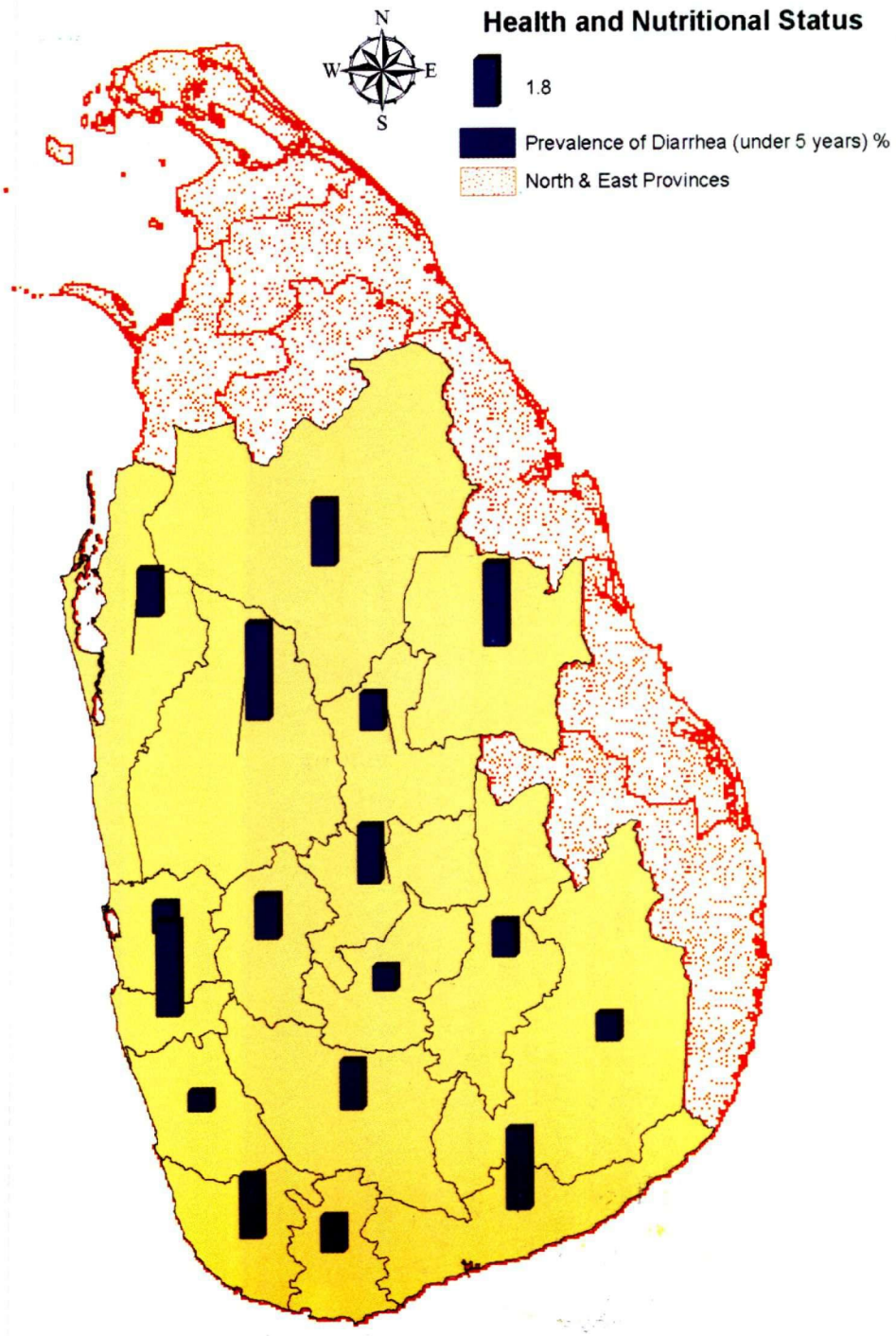


Figure 21: Percentage of the prevalence of diarrhea among children under 5 years old at district level

Figure 21 shows the distribution of the prevalence of diarrhea among children. The values are scattered. The highest figures are shown in Colombo, Kurunegala, Hambantota and Polonnaruwa districts, whereas the lowest values are shown in Gampaha, Kalutara, Nuwara Eliya, and Monaragala districts.

According to the Figures 18, 19, 20 and 21, Gampaha, Kalutara, Kegalle, Ratnapura, Nuwara Eliya, and Monaragala show low figures. Those districts also show the low level of vulnerability according to both classification methods mentioned above. Similarly, most food insecure districts, namely Colombo and Kandy, show very high figures in the above bar charts due to the adverse living conditions of some communities living in these districts. It means that there is a direct relationship between those factors and the classification output of food insecurity in terms of health and nutrition. Table 12 shows the food insecurity ranking of each district based on health and nutritional factors.

Table 12: Relative food insecurity of districts ranked based on health and nutritional variables

District	Relative Food Insecurity Based on Health and Nutrition Variables
Anuradhapura	12
Badulla	11
Colombo	17
Galle	14
Gampaha	2
Hambantota	8
Kalutara	3
Kandy	16
Kegalle	1
Kurunegala	13
Matale	7
Matara	9
Monaragala	4
Nuwara Eliya	6
Polonnaruwa	10
Puttalam	15
Ratnapura	5

3.1.4 Vulnerability Index for Other Related Variables on District Basis

This category consists of the variables which are indirectly related to food insecurity and mostly reflects health and sanitation conditions of the communities in each area.

The factor analysis revealed four factors with Eigen values more than one as well as the percentages of the Eigen values for the factors one to four are 57.0 %, 14.1 %, 10.6 % and 8.9 %, respectively. That means that the factor one contributes to more than half of the weight from the vulnerability index derived by the proxy variables. Table 13 shows the most contributing factor loadings of the variables relevant to each factor. According to

Table 13, highly affecting variables for the factors one to three are percentage of people with permanent housing units, percentage of people with permanent roofing materials, and unemployment percentage. For the factor four, it is the unemployment percentage.

Table 13: Factor loadings of variables highly affecting the category of other related variables

Variables	Values of 1st Factor	Values of 2nd Factor	Values of 3rd Factor	Values of 4th Factor
Number of Hospitals	-0.83144	0.35348	0.2864	0.01246
Number of Beds in Hospitals	0.41598	0.63584	0.41935	0.47146
Number of Medical Officers	0.74541	0.43161	0.22728	0.4047
Unemployment Percentage	-0.37212	-0.01493	-0.6809	0.55462
Number of Schools	-0.86906	0.24303	0.10061	-0.18749
Literacy Rate	0.74533	-0.48001	0.36827	0.01063
Number of People Not attending to School	0.715	-0.49558	0.34894	0.14176
Percentage of People with Permanent Housing Unit	0.93913	0.02201	-0.25664	-0.16763
Percentage of People with Permanent Floor Materials	0.8944	-0.29568	-0.23184	-0.07037
Percentage of People with Permanent Wall Materials	0.81517	0.3042	-0.05363	-0.17197
Percentage of People with Permanent Roofing Materials	0.41112	0.6601	-0.38713	-0.35547
Percentage of People with Electricity	0.91621	0.04486	-0.23729	-0.0933
Percentage of People having Convenient Fuel	0.88171	0.12442	-0.1486	0.36552
Percentage of People with Permanent Toilet Facilities	0.68251	0.29166	0.29895	-0.4152

Figures 22 and 23 show relative vulnerability derived from these other related variables. According to the natural break classification method, Colombo comes under the least vulnerable area, while Gampaha, Kalutara, Galle, and Kandy are classified into the group of less vulnerable districts. Moderately vulnerable districts are Matara and Kegalle. However, according to this classification type, most of the districts show vulnerable situations. Those districts are found in Matale, Nuwara Eliya, Badulla, Kurunegala Puttalam Ratnapura, Hambantota, Anuradhapura, and Polonnaruwa districts. Monaragala is the only district which shows the critical condition of vulnerability.

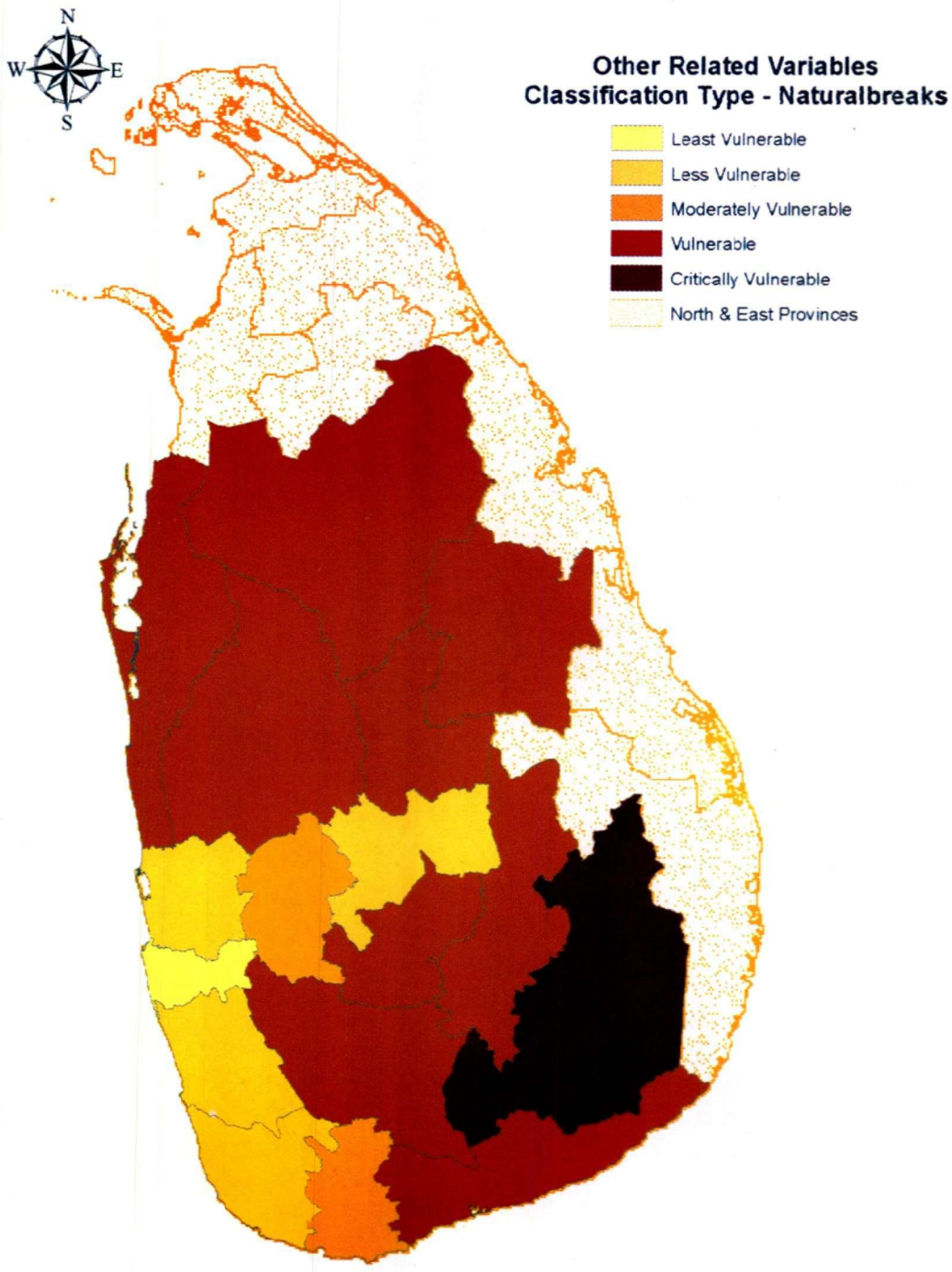


Figure 22: Relative vulnerability in Sri Lanka based on other related variables under the natural break classification

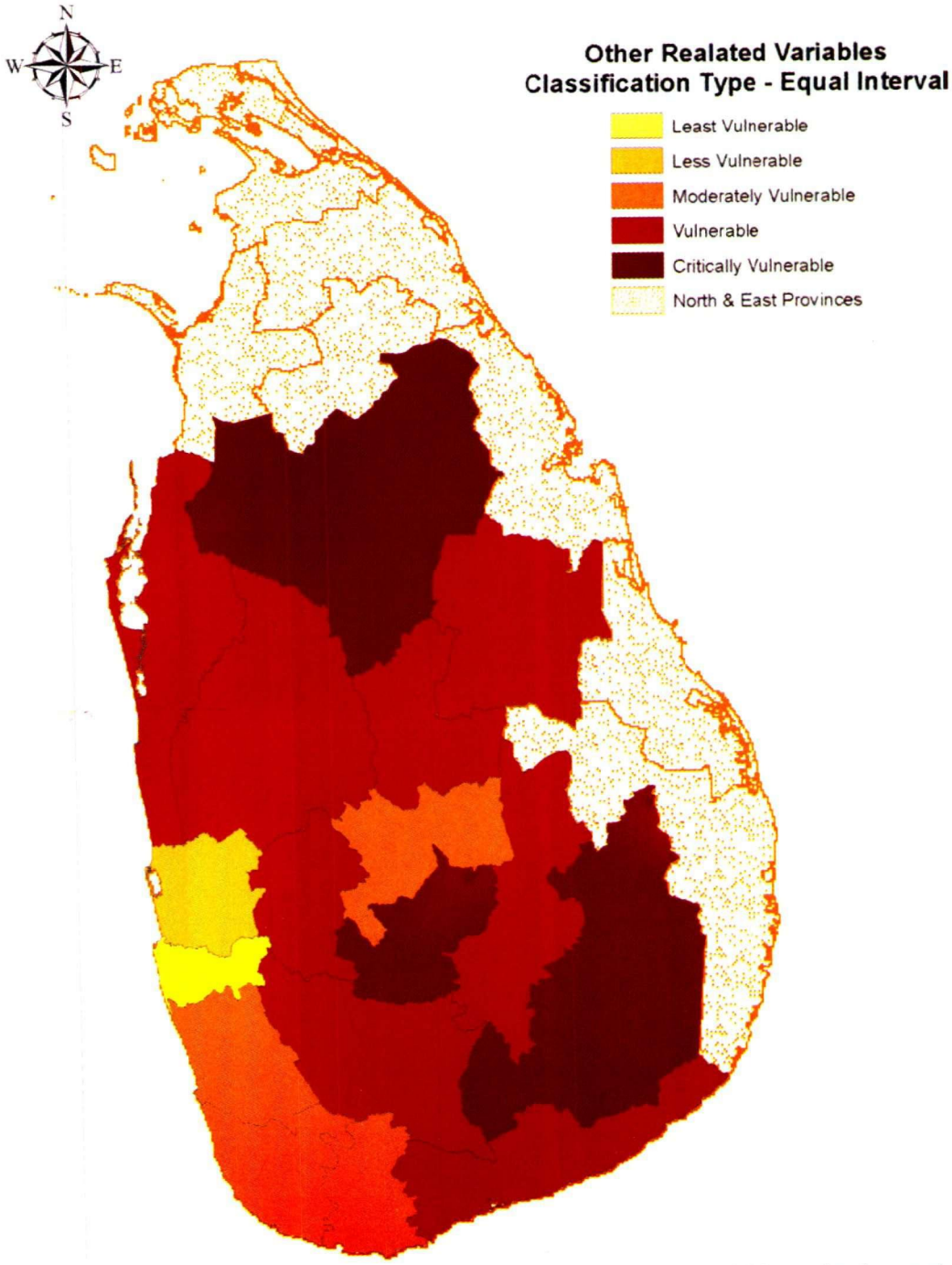


Figure 23: Relative vulnerability in Sri Lanka based on other related variables under the equal interval classification

In Figure 23 the equal interval classification method for the same vulnerability index shows different arrangements but Colombo shows the least vulnerable condition in both these classification methods. Gampaha is the only district with a less vulnerable condition, whereas Kalutara, Galle, Matara, and Kandy show moderate vulnerability according to the equal interval classification. Most of the districts such as Hambantota, Matale, Badulla, Polonnaruwa, Kurunegala, Puttalam, Kegalle, and Ratnapura come under vulnerable areas. Only the districts Nuwara Eliya, Anuradhapura, and Monaragala are found with the critical vulnerability status.

The summary of Figures 22 and 23 are given in Table 14 where both situations classify only Colombo as the least vulnerable area. The difference between the two methods is that in the equal interval classification, districts shift to the highly vulnerable direction more than the natural break classification type, although most of the districts are classified as more vulnerable areas according to the both classification types.

Table 14: Levels of relative vulnerability of districts based on other related variables under the classification types of natural break and equal interval

Vulnerability Class	Natural Break	Equal Interval
Least Vulnerable	Colombo	Colombo
Less Vulnerable	Gampaha, Kalutara, Galle, Kandy	Gampaha
Moderately Vulnerable	Matara, Kegalle	Kalutara, Galle, Matara, Kandy
Vulnerable	Matale, Nuwara Eliya, Badulla, Ratnapura, Hambantota, Anuradhapura, Polonnaruwa, Kurunegala, Puttalam	Matale, Hambantota, Badulla, Polonnaruwa, Kurunegala, Puttalam, Kegalle, Ratnapura
Critically Vulnerable	Monaragala	Nuwara Eliya, Anuradhapura, Monaragala

The largest effect for this category is given by the availability of permanent housing units as shown in Figure 24. The highest value is in Colombo, which is the least vulnerable district according to the both classification types discussed, and the lowest values are shown in critically vulnerable districts such as Anuradhapura and Monaragala.

There are 16 variables considered in this category to identify vulnerability towards food insecurity. Most of the variability that exists due to the factors not considered under the first three categories was captured here. Therefore, addition or removal of a few more variables from the list would not change the vulnerability ranking significantly. Table 15 shows the vulnerability ranking of each district based on the other variables which are not considered in the first three categories.

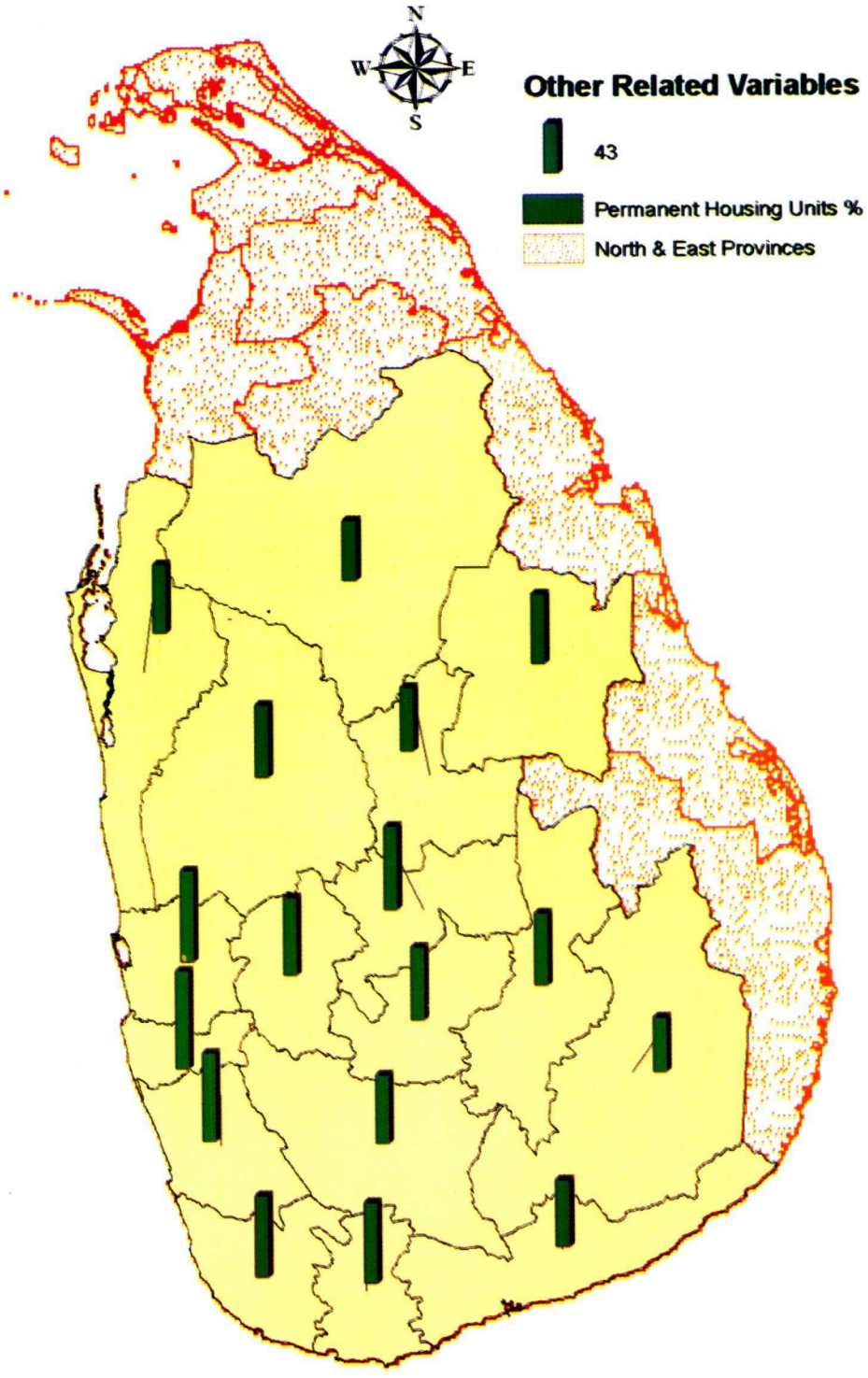


Figure 24: Permanent housing unit availability at district level

Table 15: Vulnerability ranking of districts based on other related variables

District	Vulnerability Rank based on Other Related Variables
Anuradhapura	16
Badulla	9
Colombo	1
Galle	5
Gampaha	2
Hambantota	13
Kalutara	4
Kandy	3
Kegalle	7
Kurunegala	12
Matale	11
Matara	6
Monaragala	17
Nuwara Eliya	15
Polonnaruwa	10
Puttalam	8
Ratnapura	14

3.1.5 General Overview of Vulnerability

Although a composite index itself would not explain factors contributing to food insecurity and vulnerability in detail, understanding of which is very helpful for policy interventions, a composite food insecurity and vulnerability map would provide a generalized thematic product indicating the overall status of food insecurity and vulnerability of the country. In order to develop a composite or pooled food insecurity and vulnerability ranking, factor analysis was applied for the outputs of the four themes, namely food availability based on food production, food accessibility and affordability, health and nutritional status, and other related variables. Table 16-a presents the results of the overall analysis as well as useful insights for each district than a composite and/or pooled index.

The output gives factor with Eigen value proportions of 0.6663. It indicates that the factor one represents about 66% of the vulnerable index. Table 16-b shows the weights of each category for the factor. It indicates that the impacts of the health and nutritional status category is low in the factor one and that other factors most equally contribute to the factor, while the category of other related variables has the highest impact on the composite index. Therefore, the pooled food insecurity and vulnerability index is influenced by all four categories which were considered individually on one than, the result suggests that the health and nutrition category be considered as an "outcome" food insecurity component and be excluded from the composite index model that aims to measure relative vulnerability on the other hand. The Sri Lanka FIVIMS should take this

point into consideration when conducting food insecurity and vulnerability analysis using the same methodology in the future.

Table 16-(a): Overall food insecurity and vulnerability level by district and category

Index / DSD	Relative Vulnerability Based on Food Production	Relative Vulnerability Based on Food Accessibility and Affordability	Relative Food Insecurity Based on Health and Nutrition Variables	Relative Vulnerability Based on Other Related Variables
Anuradhapura	4	9	12	16
Badulla	8	12	11	9
Colombo	17	1	17	1
Galle	16	4	14	5
Gampaha	14	2	2	2
Hambantota	5	13	8	13
Kalutara	15	3	3	4
Kandy	9	5	16	3
Kegalle	13	17	1	7
Kurunegala	1	8	13	12
Matale	7	10	7	11
Matara	12	7	9	6
Monaragala	6	11	4	17
Nuwara Eliya	11	14	6	15
Polonnaruwa	2	15	10	10
Puttalam	3	6	15	8
Ratnapura	10	16	5	14

Table 16-(b): Factor loadings of variables in the pooled vulnerability index

Variables	Values of 1st Factor
Availability based on production	-0.80029
Accessibility and Affordability	0.91755
Health and Nutritional Status	-0.51196
Other Related Variables	0.95325

The maps of the pooled food insecurity and vulnerability according to the natural break and equal interval classification types (Figures 25 and 26) show the combined effects of all the variables. According to Figure 25, Colombo shows least food insecurity and vulnerability, while Gampaha, Kandy and Galle show less food insecurity and vulnerability. Kalutara, Matara, Kegalle, Ratnapura, Badulla, and Puttalam show moderate food insecurity and vulnerability. Matale, Nuwara Eliya, Hambantota, Polonnaruwa, and Kurunegala districts show high food insecurity and vulnerability. Monaragala and Anuradhapura are the critically food insecure and vulnerable areas according to the natural break classification.

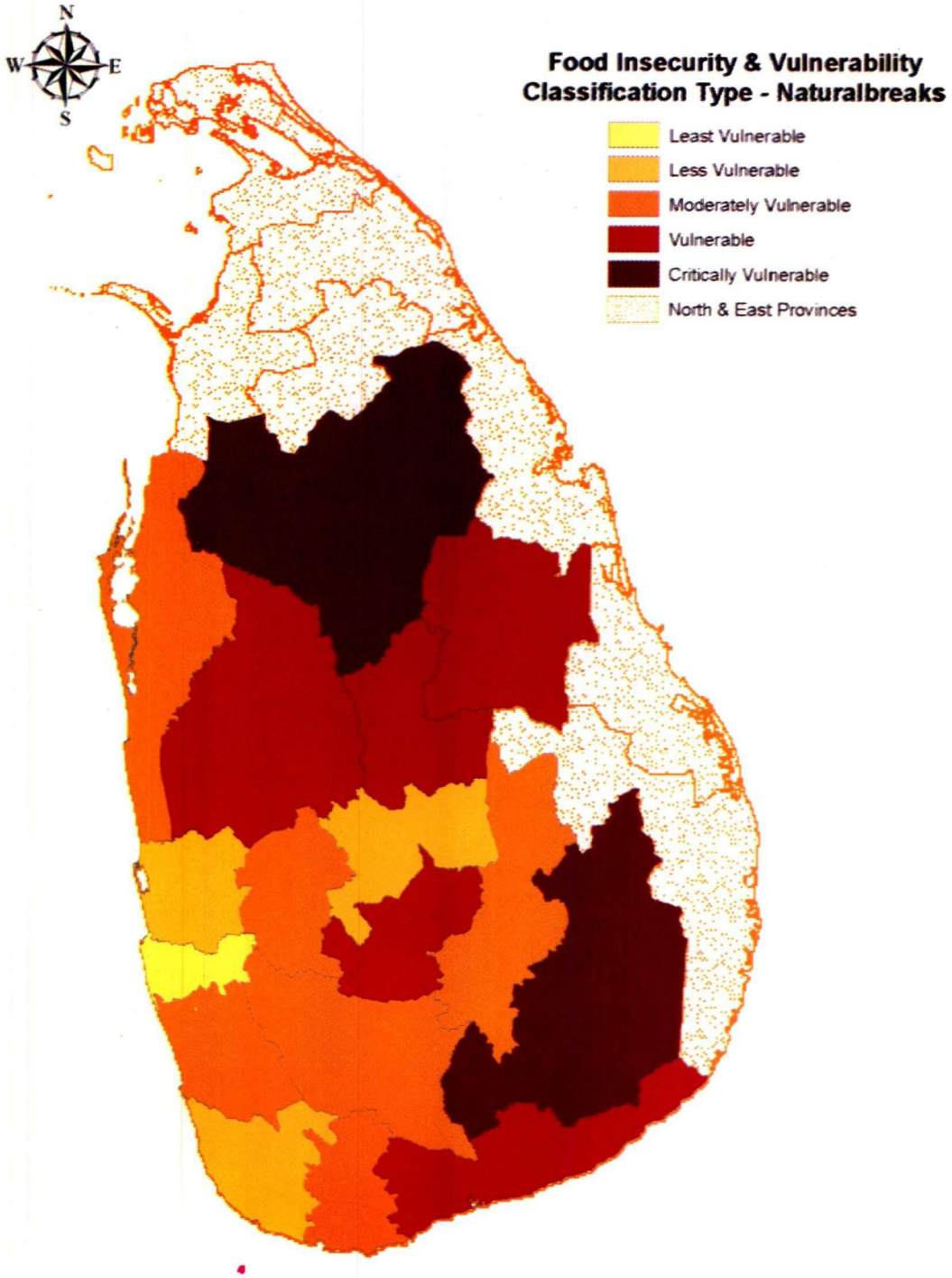


Figure 25: Relative food insecurity and vulnerability based on the pooled index under the natural break classification

However, classification had moved mostly into the direction of critically food insecure and vulnerable conditions in the equal interval method than in the natural break. Only Colombo is categorized as the least food insecure and vulnerable district and there is no district classified into the less food insecure and vulnerable group. Gampaha, Kandy, and Galle move to the moderately food insecure and vulnerable group from the less food insecure and vulnerable group according to this classification. Moderately food insecure and vulnerable districts in the natural break classification, namely Kalutara Matara, Kegalle, Ratnapura and Puttalam districts are categorized in the food insecure and vulnerable group according to the equal interval classification. Other eight districts, namely Matale, Nuwara Eliya, Hambantota, Badulla, Monaragala, Anuradhapura, Polonnaruwa and Kurunegala are classified as critically food insecure and vulnerable areas.

Table 17 shows the summary of the maps based on the pooled food insecurity and vulnerability index. Urban areas and the wet zone of the country show food secure and low vulnerable conditions, whereas most of the rural areas and the dry zone experience opposite. The food insecurity and vulnerability ranking of the districts based on the pooled or composite index is summarized in Table 18.

Table 17: Relative food insecurity and vulnerability based on the pooled vulnerability under the classification types of natural breaks and equal intervals

Class	Natural Break	Equal Interval
Least Food Insecure and Vulnerable	Colombo	Colombo
Less Food Insecure and Vulnerable	Gampaha, Galle, Kandy	
Moderately Food Insecure and Vulnerable	Kalutara, Matara, Kegalle, Ratnapura, Badulla, Puttalam	Gampaha, Galle, Kandy
Food Insecure and Vulnerable	Matale, Nuwara Eliya, Hambantota, Kurunegala, Polonnaruwa	Kalutara, Matara, Kegalle, Ratnapura, Puttalam
Critically Food Insecure and Vulnerable	Anuradhapura, Monaragala	Matale, Hambantota, Badulla, Monaragala, Nuwara Eliya, Anuradhapura, Polonnaruwa, Kurunegala

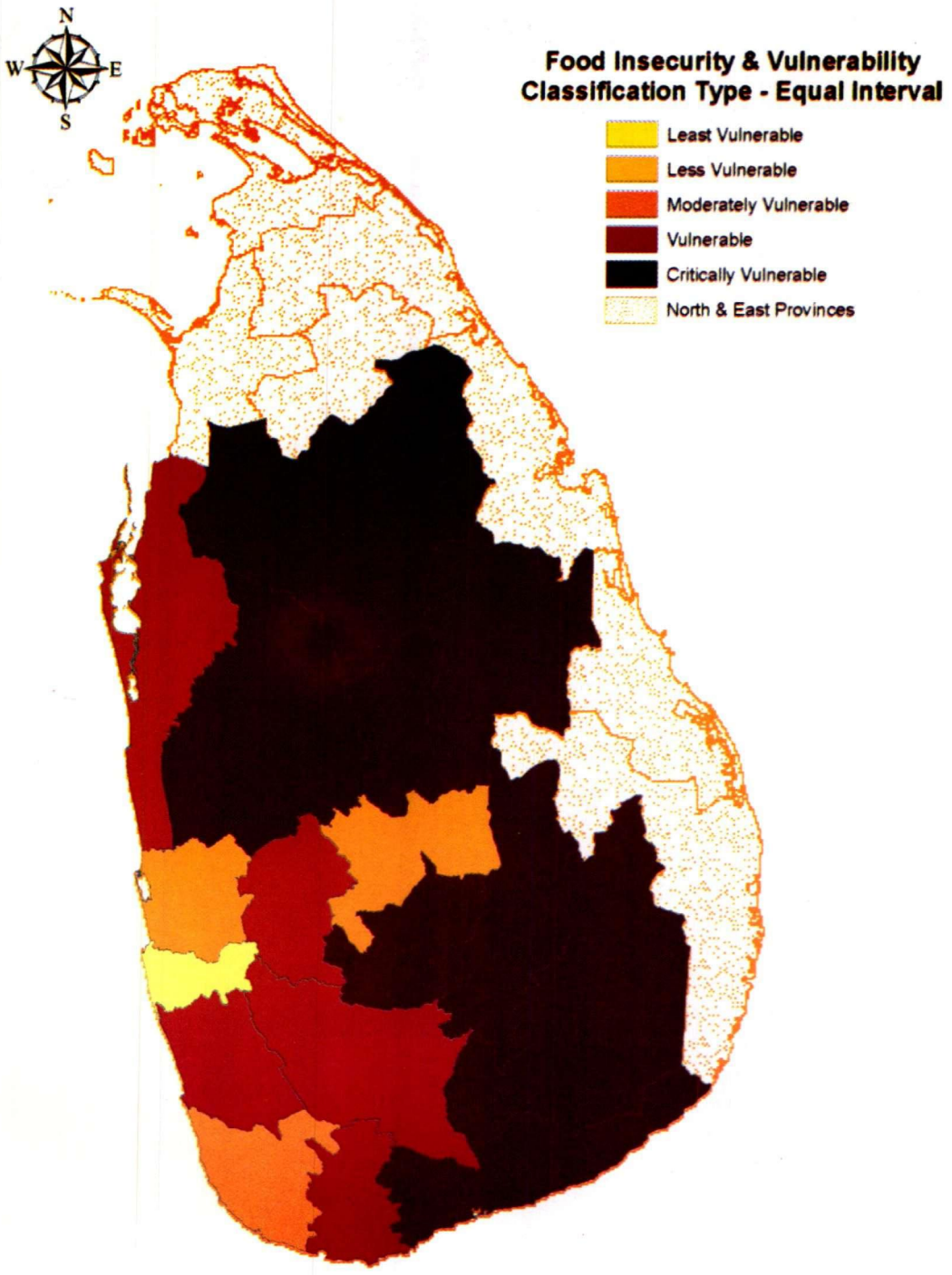


Figure 26: Relative food insecurity and vulnerability based on the pooled index under the equal interval classification

Table 18: Relative food insecurity and vulnerability of districts based on pooled variables

District	Food Insecurity and Vulnerability Based on Pooled Variables
Anuradhapura	16
Badulla	10
Colombo	1
Galle	3
Gampaha	2
Hambantota	15
Kalutara	5
Kandy	4
Kegalle	7
Kurunegala	13
Matale	11
Matara	6
Monaragala	17
Nuwara Eliya	12
Polonnaruwa	14
Puttalam	9
Ratnapura	8

3.2 Assessment of Food Insecurity and Vulnerability at Sub-National Level

In this case study, the food insecurity and vulnerability status in Monaragala district was examined at DS divisional level. (Figure 27) According to the district level analysis of the food insecurity status in Sri Lanka, Monaragala district is classified as critically food insecure and vulnerable in the composite index. In addition, Monaragala is ranked in the 6^{th}, 11^{th}, 4^{th}, 17^{th} and again 17^{th} positions according to the categories of availability, accessibility and affordability, health and nutritional status, other related variables, and pooled indices, respectively. Monaragala is also one of the rural districts and one of the mostly dry areas in Sri Lanka.

3.2.1 Vulnerability Index Based on Food Availability based on Production in Monaragala District

According to the factor analysis, three factors were given Eigen values greater than one for this category. Out of those three factors, the first one gives the weight of 51% for the final vulnerability index, and the other two factors give 20.9% and 18.4%, respectively. Table 19 shows the effect of different variables on different factors. Among others, the entire crop production variables are highly concentrated in the first factor.

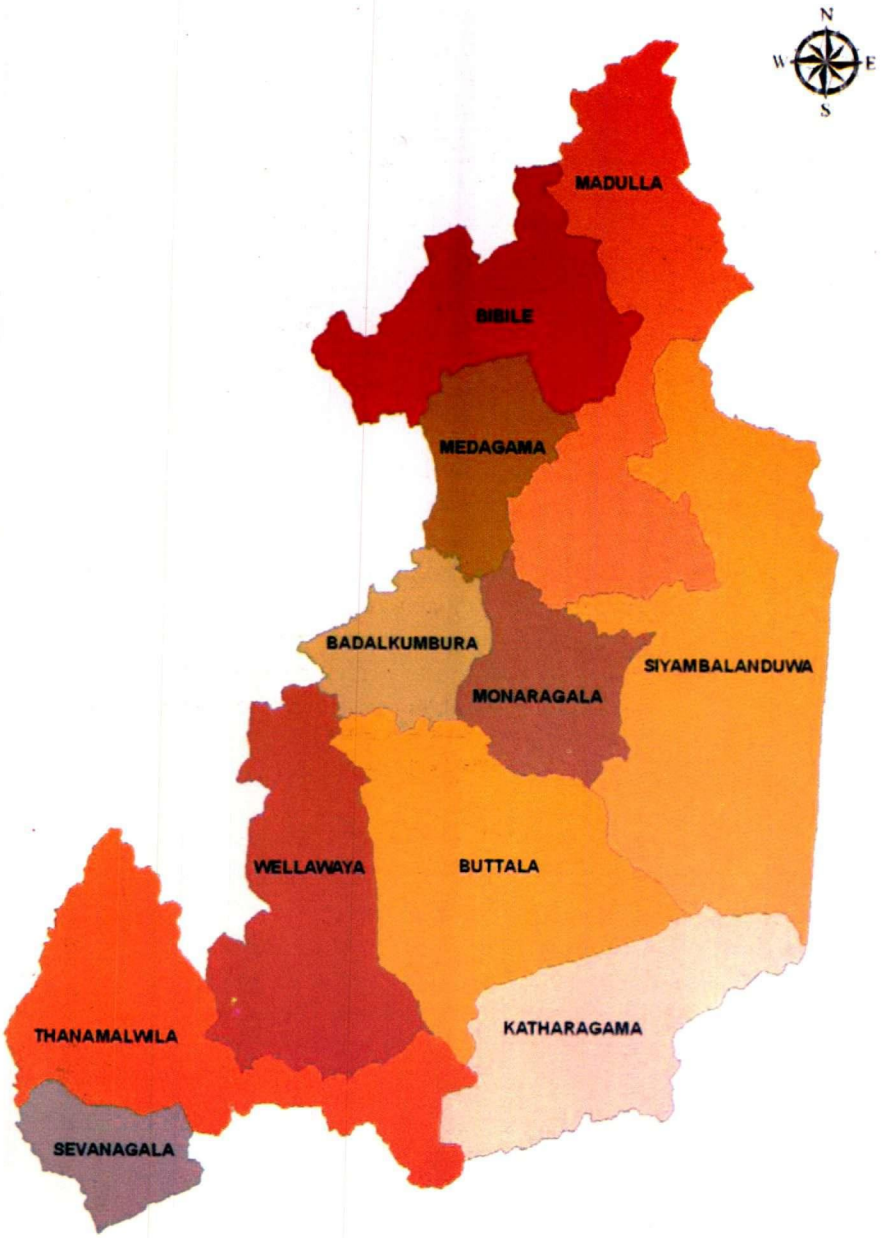


Figure 27: Divisional Secretariat Map of Monaragala

Table 19: Factor loadings of highly affecting variables in the category of food availability based on food production in Monaragala district

Variable	Values of 1st Factor	Values of 2nd Factor	Values of 3rd Factor
Population Density	0.85064	-0.46965	0.02652
Paddy Production	0.75962	0.42576	0.08941
Other Crop Production	-0.12846	0.28941	0.87338
Chena Crop Production	0.8735	0.30363	0.00815
Scrub Crop Production	0.9173	0.19741	0.27673
Production in Home Gardens	0.79684	0.30516	-0.41999
Number of Agriculture Holdings	-0.63706	0.74496	-0.08159
Agricultural Land Extent	-0.57539	0.80637	-0.05436
Animal Population	0.672	0.38156	-0.58626
Milk Production	0.59636	0.17767	0.68102

Figure 28 shows relative vulnerability in Monaragala district based on food availability according to the natural break classification method. Least and less vulnerable classes include only one DS division each: Siyambalanduwa and Thanamalwila, respectively. The moderately vulnerable class includes Wellawaya, Buttala, and Madulla, while the vulnerable class includes Badalkumbura, Medagama, and Bibila. A critically vulnerable condition is detected in Katharagama, Sewanagala and Monaragala DS divisions. However, the results could be different from the presented map if other aspects of the food availability would be considered. Food availability based on production would only indicate the degree of self-sufficiency within a single DS division, which would misinterpret the prevailing actual situation with considerable quantity of food imports.

Figure 29 depicts relative vulnerability when the equal interval classification and the same variables are considered. The map indicates that Siyambalanduwa area is grouped as the least vulnerable area, while Thanamalwila shows less vulnerability. There are no areas classified in the class of moderate vulnerability. Three DS divisions, namely Wellawaya, Buttala, and Madulla, are categorized into the vulnerable class, while most of the areas in Monaragala district such as Badalkumbura, Bibila, Medagama, Monaragala, Katharagama, and Sewanagala show critical vulnerability in terms of food availability based on production by the equal interval classification type. It should be noted that the classification is based on DS division data set of Monaragala so that the vulnerability classes defined here are not comparable with the derived statistics for district level data for the country or any other DS division analysis.

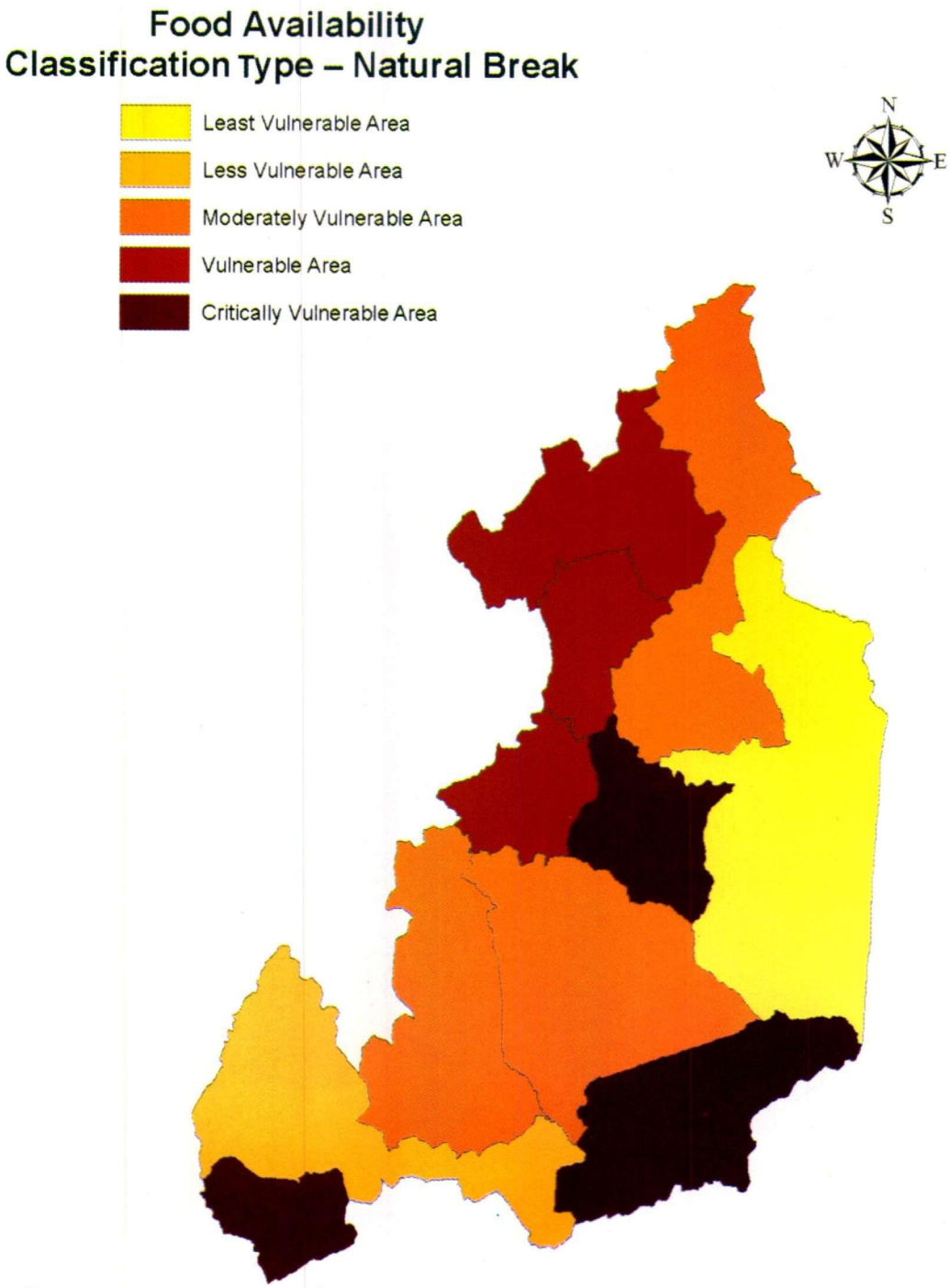


Figure 28: Relative vulnerability in Monaragala district based on food availability under the natural break classification

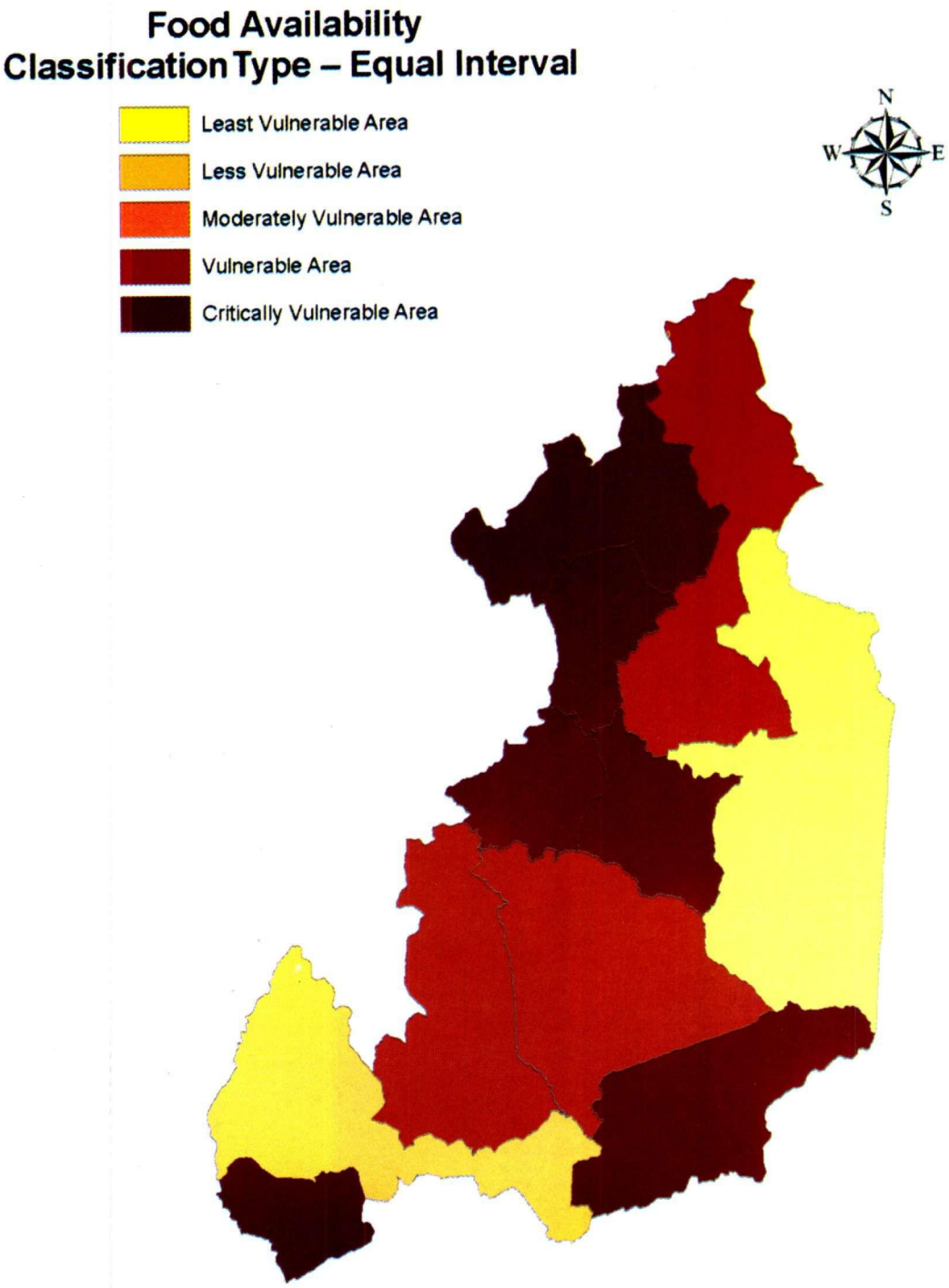


Figure 29: Relative vulnerability in Monaragala district based on food availability under the equal interval classification

Table 20: Levels of vulnerability in Monaragala district based on food availability under the classification types of natural break and equal interval

Vulnerability Class	Natural Break	Equal Interval
Least Vulnerable	Siyambalanduwa	Siyambalanduwa
Less Vulnerable	Thanamalwila	Thanamalwila
Moderately Vulnerable	Wellawaya, Buttala, Madulla	
Vulnerable	Badalkumbura, Medagama, Bibila	Wellawaya, Buttala, Madulla
Critically Vulnerable	Monaragala, Katharagama, Sewanagala	Badalkumbura, Bibila, Medagama, Monaragala, Katharagama, Sewanagala

Table 21: Relative vulnerability of DS divisions in Monaragala District in the category of food availability based on food production

Division	Vulnerability Rank based on food production
Badalkumbura	7
Bibila	6
Buttala	4
Katharagama	11
Madulla	5
Medagama	8
Monaragala	9
Sewanagala	10
Siyambalanduwa	1
Thanamalwila	2
Wellawaya	3

Figures 28 and 29 are summarized in Table 20 showing that there are no differences in least and less vulnerable groups. But the main different is that there are no districts classified as moderately vulnerable areas according to the equal interval classification. The other important point is that the urban areas of the districts such as Badalkumbura, Bibila, Monaragala, Buttala, Katharagama, etc. are classified as more vulnerable areas. Vulnerability ranks of the DS divisions based on food production variables are shown in Table 21.

3.2.2 Vulnerability Index of Food Accessibility and Affordability in Monaragala District

Vulnerability index of the variables related to food accessibility and affordability was derived from a single factor which gives 62.5% of Eigen value weight in the factor analysis. Table 22 shows the effects of different variables for the vulnerability index. Poverty is one of the major factors affecting vulnerability in any area.

Table 22: Factor loadings of highly affecting variables in the category of food accessibility and affordability in Monaragala district

Variables	Values of the Factor
Head Count Index	0.94022
Household Population Below Poverty Level	0.91845
Density of Type A Roads	-0.3859

Figure 30 describes relative vulnerability within Monaragala district based on food accessibility and affordability grouped by the natural break classification method. The map shows that Katharagama, and Sewanagala DS divisions are included into the least vulnerable group and that Monaragala and Buttala are classified as less vulnerable. Moderately vulnerable divisions are Wellawaya, Medagama, Badalkumbura, and Bibila according to the natural break classification. Madulla and Thanamalwila show vulnerable conditions, while Siyambalanduwa is in the critically vulnerable area with respect to food accessibility and affordability.

Figure 31 shows an equal interval classification of DS divisions that identify positive food security situations in Monaragala district in terms of food accessibility and affordability. It means all DS divisions show the least vulnerable situation except three: Siyambalanduwa classified as a critically vulnerable area, and Madulla and Thanamalwila, less vulnerable.

Table 23 summarizes relative vulnerability based on food accessibility and affordability according to the two classifications. It shows the equal interval classification highly shifts divisions towards the food secure direction than the natural break classification for the same vulnerability index. The vulnerability rank of DS divisions based on food accessibility and affordability is shown in Table 24.

Table 23: Relative vulnerability in Monaragala district in terms of food accessibility and affordability under the classification types of natural break and equal interval

Vulnerability Class	Natural Breaks	Equal Interval
Least Vulnerable	Katharagama, Sewanagala	Wellawaya, Buttala, Badalkumbura, Bibila, Medagama, Monaragala, Katharagama, Sewanagala
Less Vulnerable	Monaragala, Buttala	Madulla, Thanamalwila
Moderately Vulnerable	Wellawaya, Medagama, Badalkumbura, Bibila	
Vulnerable	Madulla, Thanamalwila	
Critically Vulnerable	Siyambalanduwa	Siyambalanduwa

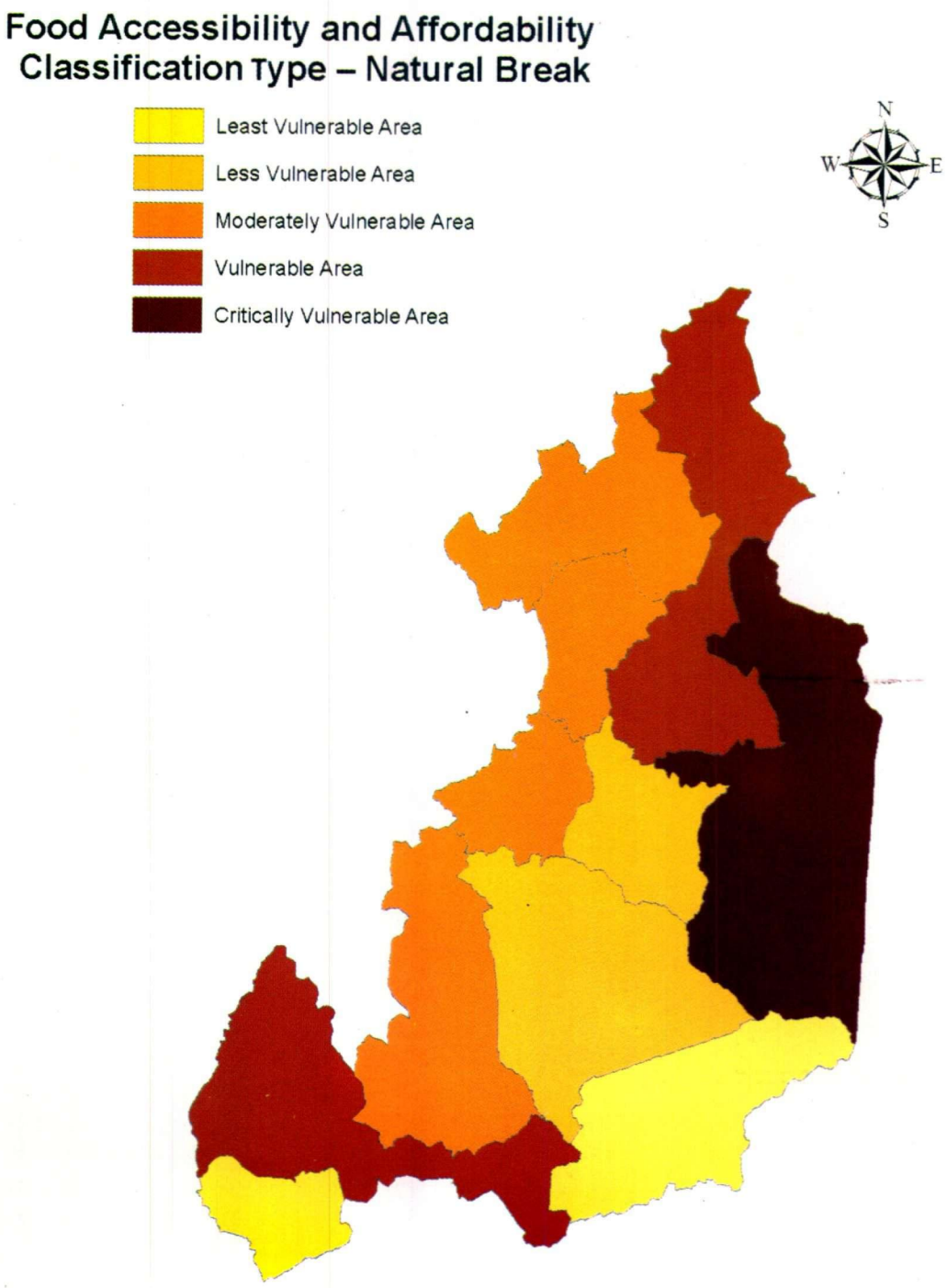


Figure 30: Relative vulnerability in Monaragala district based on food accessibility and affordability under the natural break classification

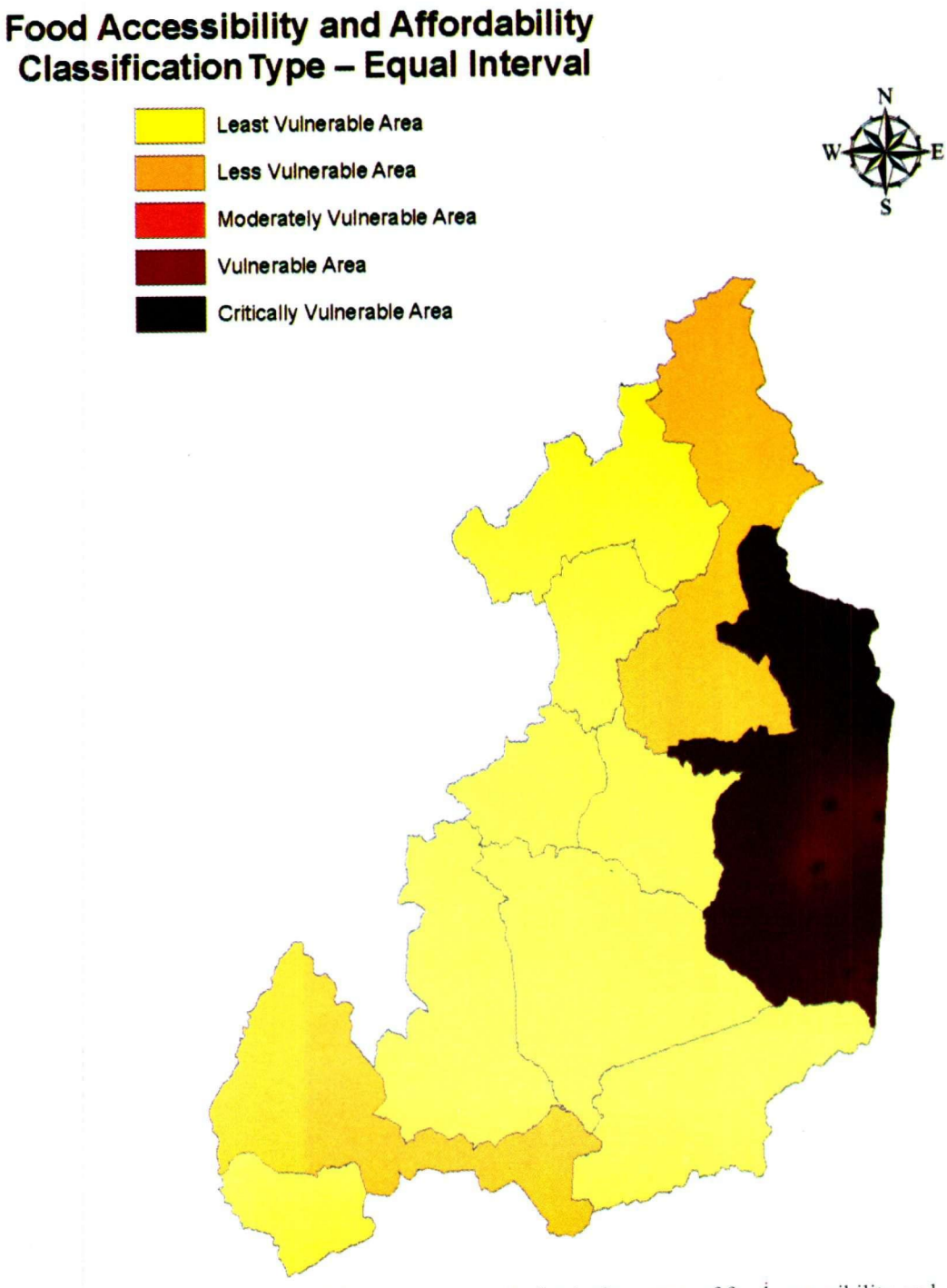


Figure 31: Relative vulnerability in Monaragala district inn terms of food accessibility and affordability under the equal interval classification

Table 24: Vulnerability ranking of Monaragala district based on food accessibility and affordability

Divisions	Relative Vulnerability Based on Food Accessibility and Affordability
Badalkumbura	6
Bibila	7
Buttala	3
Katharagama	1
Madulla	9
Medagama	5
Monaragala	4
Sewanagala	2
Siyambalanduwa	11
Thanamalwila	10
Wellawaya	8

3.2.3 Food Insecurity Index of Health and Nutritional Status in Monaragala District

The food insecurity index based on the health and nutritional status of people is derived from factor loadings of two factors which give the Eigen value proportions of 39.2% and 28%. Table 25 shows the factor loadings of those two factors and according to that all the variables affect the index.

Figure 32 shows relative food insecurity based on the health and nutritional status according to the natural break classification type. This classifies Siyambalanduwa as the least food insecure area and Thanamalwila as a less food insecure area. According to this classification, moderate food insecure areas are Buttala Bibila, Wellawaya, Sewanagala, and Badalkumbura, while Katharagama and Madulla are identified as highly food insecure. Monaragala and Medagama are the areas with critical food insecurity according to the natural break classification.

Table 25: Factor loadings of highly affecting variables in the category of health and nutritional status of people in Monaragala district

Variables	Values of 1st Factor	Values of 2nd Factor
Percentage of People with Safe Drinking Water	0.73879	0.32916
Live Birth Rate	-0.74738	0.41829
Infant Mortality Rate	0.85224	0.25686
Percentage of Maternal Deaths	-0.27413	-0.87377
Percentage of Infant with Low Birth Weight	0.66155	-0.50556
Percentage of People with Food Poisoning	-0.09727	0.56067

The map given by the equal interval classification based on the health and nutritional status of the nation in Monaragala district is shown in Figure 33. It classifies Siyambalanduwa as the least food insecure area and Thanamalwila as a less food insecure area. There are two DS divisions classified into the moderately food insecure class according to the equal interval classification, namely Buttala and Bibila, while Badalkumbura, Sewanagala, and Wellawaya are grouped into the food insecure class. Medagama, Monaragala, Katharagama, and Madulla are the critical DS divisions with respect to the equal interval classification.

Table 26 shows a comparison of relative food insecurity identified by the two classification types. The main difference between them is that there are no areas classified under the moderately food insecure group according to the equal interval classification. Table 27 shows the food insecurity ranks of DS divisions in Monaragala district based on the health and nutritional status of the people.

Table 26: Relative food insecurity level in Monaragala district based on the health and nutritional status under the classification types of natural break and equal interval

Food Insecurity Class	Natural Break	Equal Interval
Least Food Insecure	Siyambalanduwa	Siyambalanduwa
Less Food Insecure	Thanamalwila	Thanamalwila
Moderately Food Insecure	Buttala, Bibila, Wellawaya, Sewanagala, Badalkumbura	Buttala, Bibila
Food Insecure	Katharagama, Madulla,	Wellawaya, Sewanagala, Badalkumbura
Critically Food Insecure	Monaragala, Medagama	Medagama, Monaragala, Madulla, Katharagama

Table 27: Food insecurity ranking of Monaragala district based on health and nutritional variables

Divisions	Vulnerability Rank Based on Health and Nutrition Variables
Badalkumbura	7
Bibila	3
Buttala	4
Katharagama	8
Madulla	9
Medagama	11
Monaragala	10
Sewanagala	5
Siyambalanduwa	1
Thanamalwila	2
Wellawaya	6

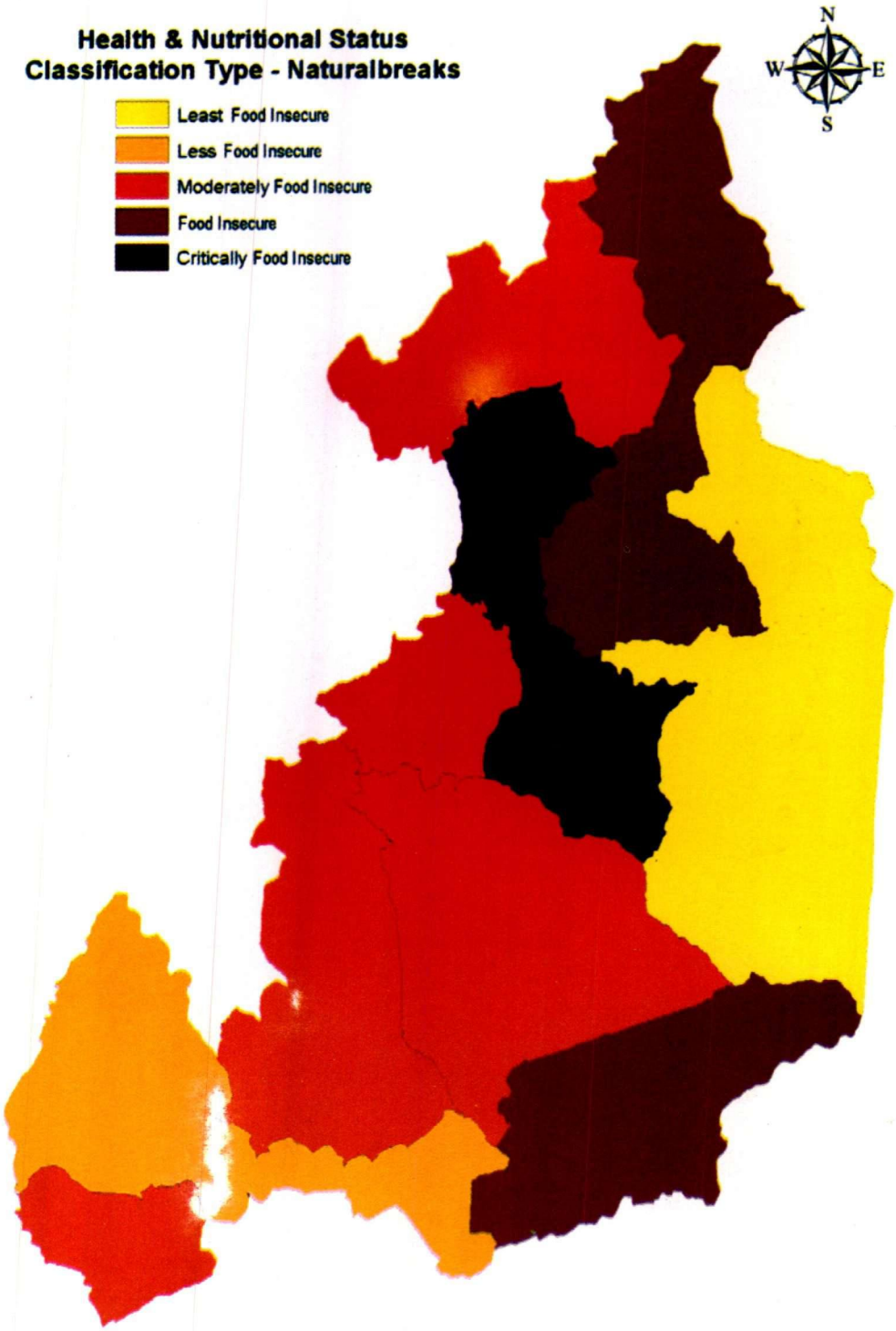


Figure 32: Relative food insecurity in Monaragala district based on the health and nutritional status under the natural breaks classification

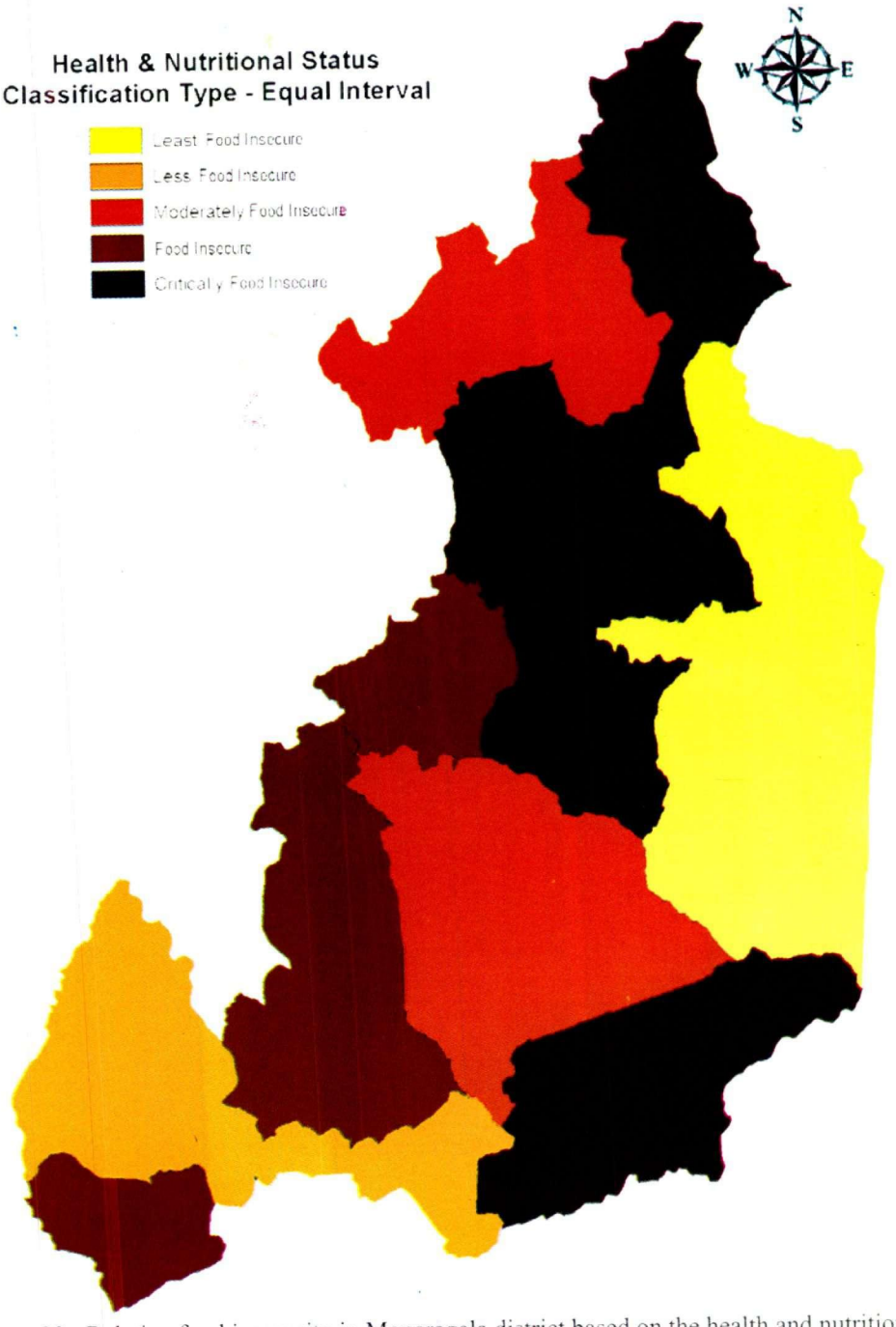


Figure 33: Relative food insecurity in Monaragala district based on the health and nutritional status under the equal interval classification

3.2.4 Vulnerability Index of Other Related Variables in Monaragala District

Other variables which are related to vulnerability give four factors with higher Eigen values that are greater than one, and those variables give the weight of 44.9%, 16%, 12.9% and 8.7% for the vulnerability index. Table 28 shows the factor loadings of those four factors according to the variables.

Table 28: Factor loadings of highly affecting variables in the category of other related variables in Monaragala district

Variables	Values of 1st Factor	Values of 2nd Factor	Values of 3rd Factor	Values of 4th Factor
Number of Schools	0.76017	-0.32296	0.48035	-0.0511
Pre School Attendance	0.60799	0.11134	0.59318	0.05832
School not Attendance	0.38205	0.83911	0.01869	-0.11891
Number of Hospitals	0.42287	-0.45503	0.71885	-0.02882
Number of Medical Officers	0.21764	0.53715	0.07985	0.28397
Percentage of Active Population	-0.36587	0.56215	0.61641	0.01617
Percentage of Unemployment	-0.38591	0.15601	0.46362	-0.16221
Percentage of People working in Agriculture Sector	-0.80114	0.27887	0.31254	0.34245
Percentage of People with Permanent Housing Unit	0.92743	-0.11426	0.02185	0.14803
Percentage of People with Permanent Wall Materials	0.88353	-0.05748	-0.16733	0.37256
Percentage of People with Permanent Floor Materials	0.9451	-0.04502	0.12263	-0.00923
Percentage of People with Permanent Roofing Materials	-0.36941	-0.72067	0.11253	0.40811
Percentage of People with Permanent Toilet Facilities	0.53747	0.33712	-0.12148	0.67965
Percentage of People with Electricity	0.94175	0.08241	-0.23979	-0.04147
Percentage of People having Convenient Fuel	0.80533	0.1196	-0.06841	-0.51697

Figure 34 depicts relative vulnerability classified by using the natural break classification as well as variables such as infrastructure facilities, living status of people, etc. The map shows that Siyambalanduwa is the least vulnerable area, and Monaragala, Medagama, and Sewanagala are less vulnerable areas. Wellawaya, Madulla, and Badalkumbura are classified into the moderately vulnerable group, while Buttala and Thanamalwila are considered as vulnerable. Katharagama and Bibila are the critical areas with respect to the natural break classification.

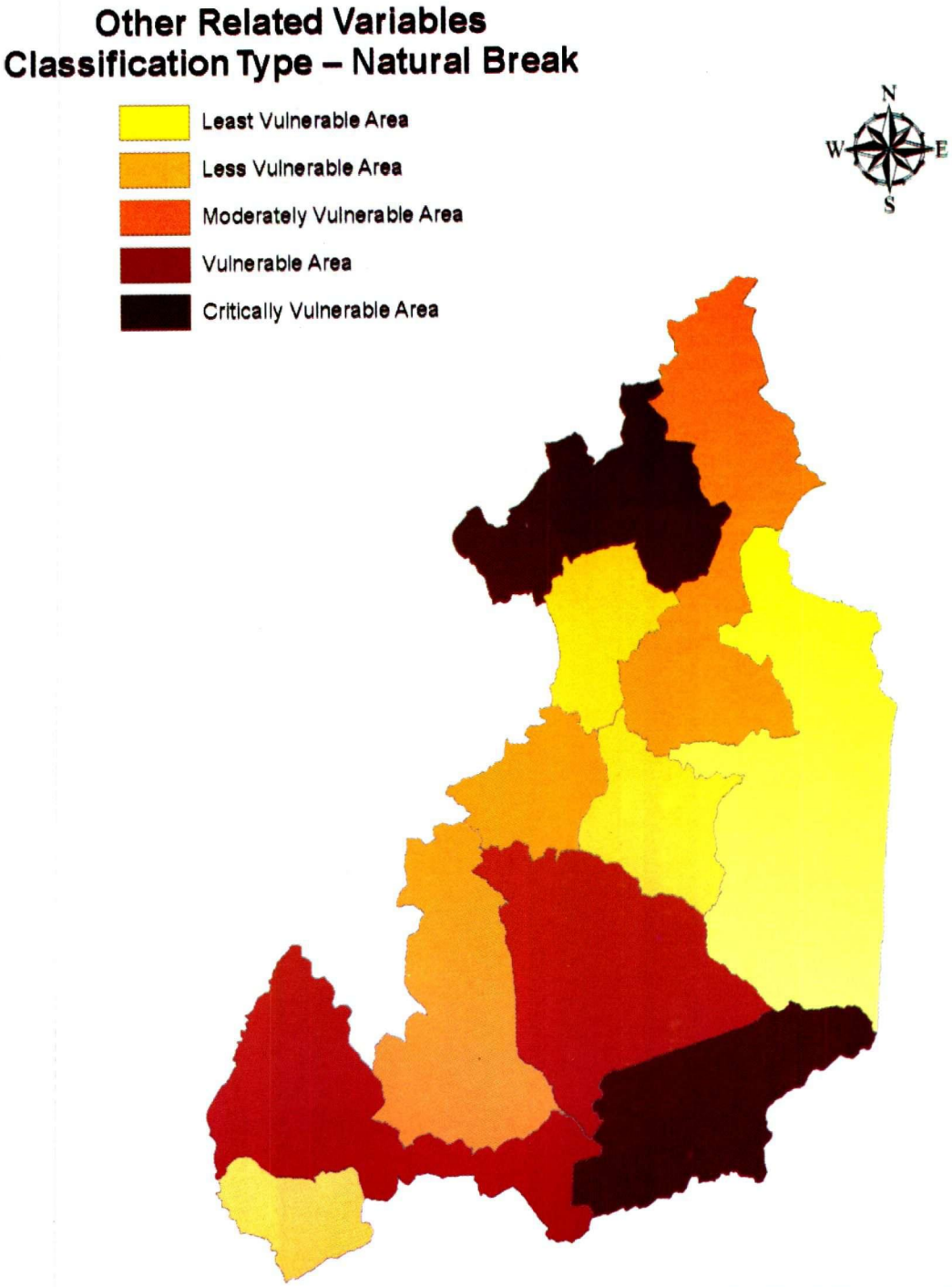


Figure 34: Relative vulnerability in Monaragala district based on other related variables under the natural break classification

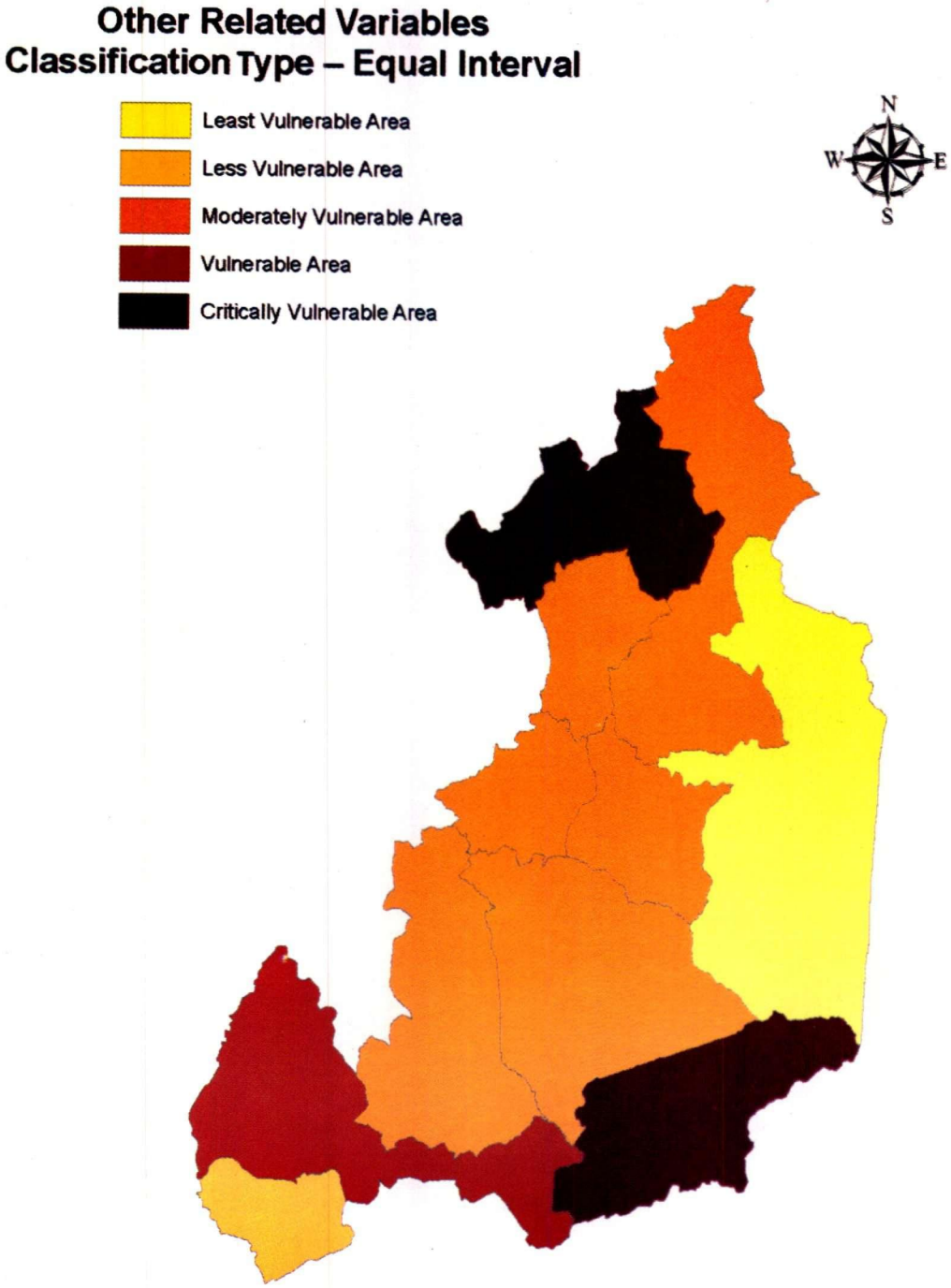


Figure 35: Relative vulnerability in Monaragala district based on other related variables under the equal interval classification

The result of the equal interval classification based on other variables related to vulnerability is shown in Figure 35. It classifies Siyambalanduwa as the least vulnerable level as is the case with the natural break classification, and Sewanagala, less vulnerable. Out of eleven DS divisions in Monaragala district, six are categorized as moderately vulnerable areas in the equal interval classification. Thanamalwila is classified as vulnerable, and Katharagama and Bibila, critically vulnerable.

Table 29 shows a comparison of the two classification types. There are no obvious differences between the two. The vulnerability index is equally distributed between its maximum and minimum range. Table 30 shows the relative vulnerability ranks of DS divisions of Monaragala district based on other related variables that were not considered in other three categories.

Table 29: Relative vulnerability in Monaragala district based on other related variables under the classification types of natural break and equal interval

Vulnerability Class	Natural Break	Equal Interval
Least Vulnerable	Siyambalanduwa	Siyambalanduwa
Less Vulnerable	Monaragala, Medagama, Sewanagala	Sewanagala
Moderately Vulnerable	Wellawaya, Madulla, Badalkumbura	Medagama, Monaragala, Madulla, Wellawaya, Buttala, Badalkumbura
Vulnerable	Buttala, Thanamalwila	Thanamalwila
Critically Vulnerable	Katharagama, Bibila	Katharagama, Bibila

Table 30: Vulnerability ranking of Monaragala district based on related variables

Divisions	Vulnerability Rank Based on Other Related Variables
Badalkumbura	5
Bibila	10
Buttala	8
Katharagama	11
Madulla	7
Medagama	4
Monaragala	3
Sewanagala	2
Siyambalanduwa	1
Thanamalwila	9
Wellawaya	6

3.2.5 Pooled Food Insecurity and Vulnerability Index in Monaragala District

The factor analysis based on the ranks of the above four categories revealed that food accessibility and affordability and food availability have the highest effect on the over or composite food insecurity and vulnerability index. This factor gives the weight of 73.7%

from the Eigen value proportion to the final index, and the factor loadings related to the four categories are shown in Table 31.

Table 31: Factor loadings of variables for the pooled food insecurity and vulnerability index in Monaragala district

Variables	Factor Values
Availability	0.96714
Accessibility and Affordability	-0.94671
Health and Nutritional Status	0.8309
Proxy Variables	0.65792

According to Figure 36 which shows the distribution of the pooled food insecurity and vulnerability index, or overall food insecurity and vulnerability, Siyambalanduwa is classified as the least food insecure vulnerable DS division, and Thanamalwila, a less food insecure and vulnerable area, when the natural break classification is used. The map also shows that Wellawaya, Buttala, and Madulla areas are ranked as the moderately food insecure and vulnerable level, while Sewanagala and Badalkumbura areas are in the food insecure and vulnerable class. The critically food insecure and vulnerable class includes Monaragala, Katharagama, Medagama, and Bibila DS divisions.

As was the case with other case studies, the equal interval classification was also used to derive an overall or pooled food insecurity and vulnerability index (Figure 37). In this classification, Siyambalanduwa belongs to the least food insecure and vulnerable class and Thanamalwila, to the moderately food insecure and vulnerable group. All other DS divisions, namely Medagama, Monaragala, Madulla, Wellawaya, Buttala, Badalkumbura, Katharagama, Bibila, and Sewanagala fall into the critical food insecure and vulnerable class.

Table 32 summarizes Figures 36 and 37 which show the pooled food insecurity and vulnerability index for Monaragala district. As is the case with all categories except the accessibility category, Siyambalanduwa is identified as the least food insecure and vulnerable area. A salient feature in this case is that the pooled food insecurity and vulnerability index, which used the equal interval classification, grouped all DS divisions except Siyambalanduwa and Thanamalwila into either food insecure and vulnerable or critically food insecure and vulnerable class. Thus, the trend of the index is towards the direction of the food insecure condition for the whole district. Table 33 indicates the food insecurity and vulnerability ranking of the DS divisions based on the pooled or composite food insecurity and vulnerability index.

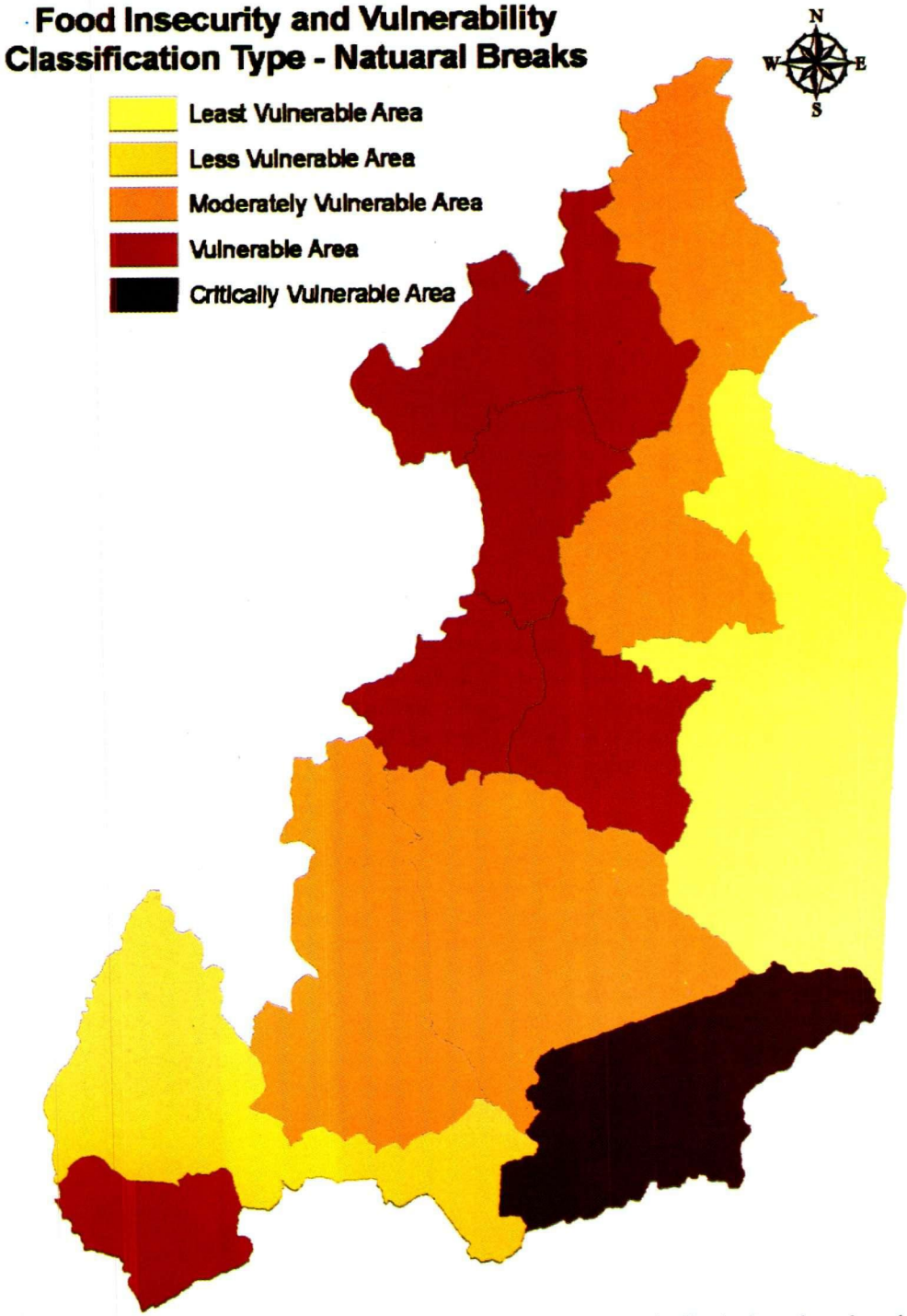


Figure 36: Overall food insecurity and vulnerability in Monaragala district based on the other related variables under the natural break classification

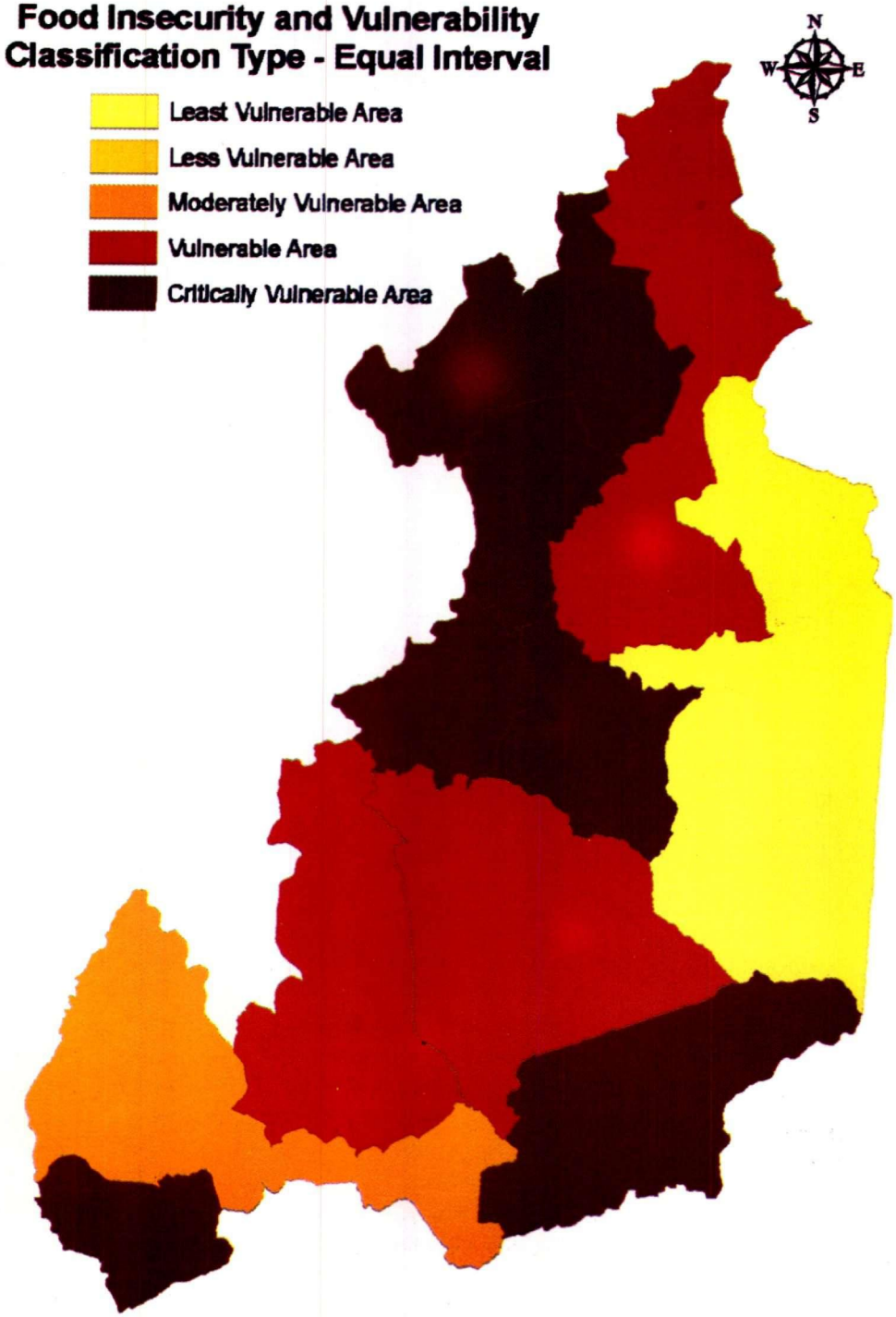


Figure 37: Overall food insecurity and vulnerability in Monaragala district based on the other related variables under the equal interval classification

Table 32: Relative food insecurity and vulnerability in Monaragala district based on the pooled index under the classification types of natural break and equal interval

Class	Natural Break	Equal Interval
Least Food Insecure and Vulnerable	Siyambalanduwa	Siyambalanduwa
Less Food Insecure and Vulnerable	Thanamalwila	
Moderately Food Insecure and Vulnerable	Wellawaya, Buttala, Madulla	Thanamalwila
Food Insecure and Vulnerable	Badalkumbura, Sewanagala, Medagama, Bibila, Monaragala	Madulla, Wellawaya, Buttala
Critically Food Insecure and Vulnerable	Katharagama	Medagama, Monaragala, Badalkumbura, Bibila Sewanagala Katharagama

Table 33: Food insecurity and vulnerability ranking of Monaragala district based on pooled variables

Division	Food Insecurity and Vulnerability Rank based on Pooled Variables
Badalkumbura	7
Bibila	8
Buttala	3
Katharagama	11
Madulla	4
Medagama	9
Monaragala	10
Sewanagala	6
Siyambalanduwa	1
Thanamalwila	2
Wellawaya	5

3.2.6 General Overview of Food Insecurity and Vulnerability

The pooled food insecurity and vulnerability index itself does not explain causing factors, an understanding of which otherwise is very useful for better resource allocation, improved targeting, effective policy making, and timely interventions. However, it provides generalized thematic information indicating an overall status of food insecurity and vulnerability in the entire DS division. Accordingly, a combined table (Table 34) is presented for the results of the overall analysis. This table would provide an overview of the food insecurity and vulnerability status for each DS division under different categories and more useful insights than a composite or pooled index.

Table 34: Ranking of DS divisions based on the indices of individual categories

Index / DSD	Relative Vulnerability Based on Food Production	Relative Vulnerability Based on Food Accessibility and Affordability	Relative Food Insecurity Based on Health and Nutrition Variables	Relative Vulnerability Based on Other Related Variables
Badalkumbura	7	6	7	5
Bibila	6	7	3	10
Buttala	4	3	4	8
Katharagama	11	1	8	11
Madulla	5	9	9	7
Medagama	8	5	11	4
Monaragala	9	4	10	3
Sewanagala	10	2	5	2
Siyambalanduwa	1	11	1	1
Thanamalwila	2	10	2	9
Wellawaya	3	8	6	6

CONCLUSIONS

A standard set of variables which describe food insecurity and vulnerability accurately has not yet been agreed upon in Sri Lanka. Also it is not possible to define an empirical relationship as the status of food insecurity and vulnerability could change with time and space. Further, data availability of the defined parameters would pose a question in introducing such empirical relationships in different countries. With these constraints, the study classified a large number of variables into the four main categories referring to the general conceptual framework of FIVIMS and utilizing factor analysis to reduce the dimensionality of data into a few manageable factors. These variables were selected within the broad conceptual framework of FIVIMS through consultations with a large number of experts using the expert opinion approach.

The results of this study show that the status of food insecurity and vulnerability for each district, which was estimated by using the variables selected by FIVIMS, has a significant spatial variability across the country. Further, this study clearly demonstrates the vulnerability of the methodology adopted for mapping the final outcomes of the analysis. Both natural break and equal interval classification methods could be used for identifying relative food insecurity and vulnerability levels but the exact class of each spatial unit could vary depending on the methodology adopted, variables used in the analysis, spatial resolution of the data, period for which data were collected, etc. Therefore, different assessment exercises could result in different map products. However, the addition or removal of a few more variables from the analysis would not change the food insecurity and vulnerability ranking or grouping as most of the variability has been captured by the other variables. Since the map products could vary with the methods that were used for the analysis and also according to the classification method, an introduction of standard methods for this kind of analysis should be strongly encouraged.

An important element that needs to be addressed in the overall analysis is defining the relative vulnerability status of a given spatial unit with respect to the situation elsewhere. Likewise the key contributing factors of food insecurity and vulnerability should be considered in introducing mitigation measures. Since an area classified as food insecure on a map might be shown as a food secure place in another map if different variables are taken into consideration, individual estimations of food insecurity and vulnerability for each category along with a listing of causative factors appear to be the most useful end product of this exercise, whereas the composite index of food insecurity and vulnerability could have a more limited scope in the application. The category wise analysis helps to identify different factors to be considered for planning interventions and mitigation measures. Also the pooled or composite food insecurity and vulnerability index provides the general idea of the country, and it is important to assist policy makers by better identifying and characterizing the national food security problems.

To improve the identification of vulnerable areas or populations by the Sri Lanka FIVIMS in the future, it is suggested that (i) the health and nutrition category that reflects the outcome food insecurity situation be excluded from the computation of the overall

vulnerability index that, in principle, is derived from analysing causing factors or variables; (ii) an attempt be made to process all variables together under the categories of food availability, food accessibility/affordability, and other related factors in order to derive a composite vulnerability index, rather than estimating it by pooling together the indices of each category; (iii) vulnerable district or DS division profiles be developed to assist policy and decision makers to better understand food insecurity and vulnerability; and (iv) link FIVIMS more closely with other national initiatives involved in food insecurity and vulnerability information collection and analysis for Northern and Eastern provinces such as the Centre for Information Resources Management.

The availability of data restricted this study to the analysis at district level excluding the Northern and Eastern regions. However, to demonstrate the feasibility of the methodology at varying spatial resolutions, a DN division level study was conducted for Monaragala district. It would be much useful to identify food insecurity and vulnerability at higher spatial scales such as DS and GN divisions. Yet, it should be noted that since the food insecurity and vulnerability categories defined for Monaragala are unique to the district, interpretations based on a comparison of the categories across different districts at DS level is not applicable.

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