ABSTRACT

Remote sensing and geographic information system (GIS) technologies have the potential to be used for mapping of malnutrition cases and study the significance of environmental degradation with the cases distribution. Both technologies have the capability to link and update the information on the environmental changes, weather conditions, and cases through the online system. In this study, we used remote sensing data such as IKONOS image (1 meter resolution), Landsat TM, SPOT5 and Radarsat to provide data on the landuse changes, soil moisture, Normalized Difference Vegetation Index (NDVI), Digital Elevation Model (DEM) and flood-prone area. The advantages of using remote sensing technology are it can cover a wide and extensive area, short time collecting information on ground and availability of getting data rapidly. The objectives of this study are to establish relationships between environmental deficiencies for malnutrition cases using remote sensing data and a geoinformation system; develop a spatial and non-spatial environmental health database; monitor malnutrition distribution cases; identify populations in need of assistance, help evaluate nutritional and health interventions; provide up-to-date information for decision making and raise political awareness of nutritional problems. Location of these children is then plotted on the map using Global Positioning System (GPS). Medical records of 7119 children were reviewed using a purposely-designed internet-linked growth monitoring program (USM Growth Monitor™). Based on this prevalence, another follow-up cross-sectional study was conducted among 314 mothers of under-five children, randomly selected from the same geographical area. All the data were then stored in the GIS database. These data were then correlated to each other using the GIS spatial analysis and modelling technique. The Weighted Overlay function was chosen as the modelling technique in order to identify the malnutrition risk area. The utilization of remote sensing data such as landuse, NVDI, soil moisture DEM and flood-prone area have significantly proved to be useful in identifying environment factor contributing to malnutrition. Efforts such as the introduction of programs like the “One Village, One Agro-based Industry” to these villages would help generate additional income for the villagers.

KEY WORDS: Malnutrition, Remote Sensing, GIS, Tumpat

INTRODUCTION

Malnutrition remains a major burden to our population and is frequently a part of a cycle that includes poverty and disease. This is more pronounced in children as malnutrition in early periods of life originating from factors as poor food quality and insufficient food intake can lead to significant morbidity in future. The problem is still seen especially in areas of hunger map that has been defined by FAO. In this hunger map, Malaysia falls in the medium group (10% - 19%) on percentage of underweight children under five years. It is a nation with the lowest to have problems with insufficient access to food. The irony is, although Malaysia is considered an emerging nation, problems with malnutrition are still seen in the remote areas of the population.
Environmental conditions are known to influence the distribution of malnutrition cases among children. The relationship is well established and was taken into account in the conceptual framework introduced by UNICEF\(^3\) in the early 90s as shown in figure below.

![Conceptual Framework for Malnutrition (UNICEF 1990)](image)

Figure 1: Conceptual Framework for Malnutrition (UNICEF 1990)

It is seen in this framework, that children remains a major vulnerable group. The World Health Organization\(^4\) has recommended a way to assess malnutrition at population level by using weight and height measurement, from which, relevant anthropometric indices are constructed. The three most commonly used are weight-for-age, height-for-age and weight-for-height. When expressed in term of z-score, percentile, or percentage of medium this enables comparison of a child to a reference population be done.

The vulnerability of children to environmental factors that determine their health is well known. Primary care givers of the children with adequate access to health services, living in the healthy environment (sanitation facilities, safety of drinking water, suitable for food production, climate changes, soil fertility and good drainage system) would contribute positively to proper child care. Ability of household to translate resources to achieve food security, care and healthy environment are however limited by other factors including political, economic, cultural and geographic factor which will further determine the children nutrition status\(^5\).

Food security for family is also affected by climatic condition which will determine vegetation growth and give estimation of end season crop yield that can be correlated by famine. Information on soil moisture, crop fertility (NVDI), flooded area and landuse would also be contributing to vegetation growth. Such data could be obtained form Remote Sensing such as the one developed by the Regional Centre for Mapping of Resources for Development (RCMRD)\(^6\). Geoinformation System and Remote Sensing combined would give researchers a complete database of malnutrition cases and the environment to support decision-making on monitoring and managing malnourished child in any region.
OBJECTIVE

The specific objectives of this study are to; establish relationships between environmental deficiencies for malnutrition cases using remote sensing data and a geoinformation system; develop a spatial and non-spatial environmental health database; monitor malnutrition distribution cases; identify populations in need of assistance, help evaluate nutritional and health interventions; provide up-to-date information for decision-making and raise political awareness of nutritional problems.

STUDY AREA

Tumpat district of Kelantan (102°04’43”E, 06°14’11”N; 102°14’59”E, 06°05’20”N) is reported to have the highest cases of malnutrition in Malaysia. Geographically, Tumpat is a low land area and faces the monsoon flood during each year-end. There are five major activities conducted in Tumpat, namely paddy planting, aquaculture, cash crops, service workers and governmental department activities. The district is divided into seven mukim (counties), namely Tumpat, Pengkalan Kubor, Jal Besar, Terbak, Kebakat, Wakaf Bharu, and Sungai Pinang.

METHODOLOGY

The methodology of this study can be divided into five major activities, which are data acquisition (satellite data, meteorological data and other ancillary data), health survey, processing of acquired data, creating a GIS database as well as spatial analysis and modelling.

On the data acquisition requirement, satellite data like IKONOS, Landsat TM, SPOT and Radarsat have been chosen to provide information on landuse changes, soil moisture, crop fertility, identification of flood prone areas, and creation of a digital elevation model. Other ancillary data such as meteorological data (rainfall, humidity and temperature), demographic data, health survey and clinical data of malnutrition cases are also important for the analysis. Information on the health status of the study area was used to support the analysis in mapping malnutrition risk areas.
Three hundred and fourteen mothers were interviewed using a structured questionnaire for this study throughout the Tumpat district. The questionnaires were used to collect data on demography, socio-economic status, health status, activity pattern, nutrition knowledge, and dietary intake.

All malnutrition cases data were collected from the government clinics in Tumpat by using the anthropometric measurements (weight-for-age) based on WHO growth chart to identify the malnourished children. Those with Standard Deviation scores below than minus 2SD are considered as underweight (low weight-for-age). A total of 26 clinics in the study area were included for the study.

Detailed information of landuse/cover changes was extracted from the Landsat TM and SPOT 5 satellite imagery by using the supervised classification technique. Other data included were information on soil moisture and the Normalized Difference Vegetation Index (NDVI) from the Landsat TM data. The NDVI map was derived from the Landsat TM image by using the visible and near-infrared bands, while the soil moisture information can be extract using the Tesseled Cap function in the Erdas Image remote sensing & GIS software. The topography pattern showing the Tumpat terrain contours were obtained from the National Land & Survey Department while the Digital Elevation Model (DEM) was obtained from the Radarsat satellite image.

All the data were then stored in the GIS database. These data were then correlated to each other by using the GIS spatial analysis and modelling technique. The Weighted Overlay function was chosen as the modelling technique in order to identify the malnutrition risk area.

RESULT AND DISCUSSION

Malnutrition distribution Vs nearest health clinic

There are 26 clinics operating over the study area with an average cover range of between 1.5km to 2.5km per clinic.

Figure 3: Map of nutritional status by clinic in Tumpat
Figure 3 shows the nutritional status of the study area. The green bar refers to normal children, yellow for the group at risk of malnutrition, while the red bar stands for z-score values below than minus 2SD. The following clinics, KD Kg. Tujuh(1), KD Kok Pasir(2) and KD Kok Keli(3) have a z-score rating below than –2SD that are higher than the number of groups considered as ‘Normal’ and ‘At Risk’ of having malnourishment problem. Through the use of the buffer analysis function in the GIS software, the result shows that the locations of the government health clinics do not contribute factor to the number of malnutrition cases. Most of the areas with malnutrition cases were covered by the clinics for the health services.

From the preliminary data collection, a total of 7056 children aged below 5 have been screened. Majority of the subjects are Malays with mean age of 21.52 months, with 51.4% were male and 48.6% were female. Figure 4 shows the percentage of nutritional status in Tumpat. 69% was identified as being normal, 20% moderate undernutrition, 10% severe undernutrition and 1% for overweight.

The distribution of malnutrition percentage by clinic is shown in Figure 5. Based on the WHO standard the percentage of malnutrition cases is categorised as; low (<10%), medium (10-19%), high (20-29%) and very high (>30%). From this analysis, 47% of the clinics were considered in “Very High”, 54% were “High” and 4% were “Medium”. Therefore the overall status of malnutrition in Tumpat can be considered as “High” reinforcing the data from health ministry data described above.
Mother’s education level

The education level in the Tumpat can be seen in Figure 6. From the above figure, it can be surmised that the education level is quite low for this district with the majority of the population receiving primary and secondary as their highest education level.

Remote sensing data on study area

Remote sensing data was used to derive environmental variables such as landuse, soil moisture, Normalized Difference Vegetation Index (NDVI), Digital Elevation Model (DEM) and flood prone area.
A Landuse map of Tumpat was generated from the SPOT 5 (2.5m) satellite data in order to obtain up-to-date information. Figure 7 shows that the study area contains various types of landuse including; aquaculture, cleared land, coconut, construction area, mangrove, mixed horticulture, paddy, sandy, settlements, shrub, tobacco, urban and water.

![Figure 7: Landuse Map of Tumpat](image)

**Figure 8: Soil moisture map for Tumpat and**

Soil moisture map was obtained from the Landsat TM data by using the Tasseled Cap Function on the ERDAS Image software. Figure 8 shows areas with potential to be used for agriculture as high moisture content (shows in blue colour) can be identified as areas that could be beneficial to the crop production income. Majority of the malnutrition children were located at high moisture areas while their parents were primarily involved in service-related activities (carpenter, labourer etc.).

![Figure 8: Soil Moisture Map](image)

**Figure 9: Normalized Difference Vegetation Index (NDVI)**

NDVI in Figure 9 is used to derive the vegetation index from satellite images. It identifies areas which indicate healthy vegetation. The green colour refers to the high value of NDVI, while the white colour for low NDVI values which can also be interpreted as being built-up areas.
Generation of Digital Elevation Model (MAP) for the Tumpat shows that the district is flat in nature. The average height of the terrain is only slightly higher than sea level. As a result, floods annually inundate the district during the year-end rainy season (North-East Monsoon) as seen from series of Radarsat data during monsoon season from 1998 to 2004.

**Identification of Flood prone areas from Radarsat data**

During the North-East monsoon season, the main economic activities of the district which is agriculture (paddy & tobacco) & aquaculture will be negatively affected because of the flood inundation. It is widely accepted that an increase in cholera & diarrhoea cases (two contributing factors to malnutrition) can be expected during any major flooding event as a result of bad water quality. Flooding also disrupts the transportation system & the health services of the Tumpat district. Therefore it can be surmised that the annual monsoon-flooding event indirectly contributes to the number of malnutrition cases in this area. In order to monitor the extent & duration of the annual flooding event, the Radarsat satellite data was chosen as its sensor can penetrate through rain clouds irrespective of any weather conditions.
Risk Mapping of Malnutrition Areas

All the environment variables derived from remote sensing were combined with three other ancillary data, namely the number of malnutrition cases, age of children below 5 years and the average income of the inhabitants of the district. Income is an important factor to be considered as it is a major contributor towards the rise of malnutrition as most foodstuffs with a higher nutritional value will be out of their financial means.

The Weighted Overlay Function is a technique for applying a common measurement scale of values to diverse and dissimilar inputs in order to create an integrated analysis. The function was used to give specific priority values to the analysis results based on the requirements of this study. Values that contribute greatly towards malnutrition were given ratings as “Very High”, the second highest contributor was then rated as “High”, mild contributors were rated as “Medium” and the low contributors were given the “Low” value rating. From the results, areas that stand a risk of having malnutrition cases in the Tumpat district are shown in Figure 16 (1, 2 and 3). These are the vulnerable areas that require special attention for intervention.
DISCUSSION

Geographical factors have important roles in influencing child care development. It is seen from the result above that majority of the malnourished were children living in flood prone areas, mix horticulture and high moisture soil. Other data also shown that the primary occupations are service related activities. Lifestyle modification such as job switch from service related to agriculture related activity maybe appropriate in view of the detailed geographic and climatic data obtained in this study. The usage of land that can yield crops before the monsoon season would improve the economic status of the family and reducing the number of malnutrition cases. Efforts such as the introduction of programs like the “One Village, One Agro-based Industry” to these villages in order to help generate additional income for the villagers, might be worth attempting in order to improve their economic status.

CONCLUSION

The creation of a malnutrition database may be able to provide accurate information on the nutritional status in Malaysia. The information can be used for Ministry of Health to monitor and analyze the nutritional status of any areas under observation. Usage of the Malnutrition Risk Map could create more efficient system of supplementary feeding programs and food aid basket programs. Other ministerial efforts such as malnutrition monitoring, distribution of food funds and nutrition education efforts could also become more streamlined with focus being given to the targeted areas.

As the income factor has been identified as being a strong contributor to malnutrition cases, officials from the Ministry of Rural and Development could also use this risk map in order to identify areas that require their immediate attention.

RECOMMENDATION

The study found a great potential for the application of remote sensing and GIS techniques in this study or other similar scenarios. With the obtained results, the health authorities can perform activities such as monitoring and mitigation efforts more effectively. For a more precise result, other factors such as health condition of inhabitants (diarrhoea, cholera, malaria etc.) could be included in order to create a more precise risk map.
REFERENCES


