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GIS Visualization of Population Censuses in Peninsular Malaysia: A Case Study of Jempol, Negeri Sembilan, 1947-2000

Mohd. Shahrudin Abd. Manan* **and Nor Rasidah Hashim**
Department of Environmental Science,
Faculty of Environmental Studies,
Universiti Putra Malaysia, 43400 UPM,
Serdang, Selangor, Malaysia
**E-mail: am_shahrudin@putra.upm.edu.my*

ABSTRACT

Census has become an important administrative tool for governments to trace and plan for national progress since it contains essential information about the populations. Studies of economics, sociology, history, rural development, and agriculture commonly used censuses. Nevertheless, these studies mostly focus on the textual and numerical analysis of the census data without paying much attention to the sense of space of the censuses. Hence, Geographic Information System (GIS) could help by enabling population censuses to be spatially visualized and analyzed. In this study, two common techniques in GIS were used to spatially visualize human population censuses of Jempol district, Negeri Sembilan in the 20th century. Using GIS, the available population census data of the district were transformed into choropleth and cartogram maps of population density. The two types of map were then compared based on their usefulness and appearance in visualizing the censuses. It was found that each type of maps has its own strengths and weaknesses, but overall, the application of GIS has been found to be an exciting and reliable medium for the spatial analysis and visualization of the censuses. The findings suggest that GIS adds another dimension in understanding past demographic phenomena in the study area. It is recommended that further research in this area, such as overlapping the spatial analysis with topographic elevations and socio-economic characteristics, as well as constructing linear and non-contiguous cartograms, should be conducted. Besides enhancing the spatial analysis of the censuses, this research paves way for the development of Historical GIS studies in Malaysia.

Keywords: Human population censuses, spatial analysis, Historical GIS

INTRODUCTION

A population census is 'the total process of collecting, compiling and publishing demographic, economic and social data pertaining, at a specified time or times, to all persons in a country or delimited territory' (United Nations, 1958, p.3). Censuses have become an important administrative tool for governments in tracing and planning for national progress. By correlating the number of people with socio-economic factors, such as job employment, commodities export, and income distribution, a sound planning for the national progress could be made.

Population census in Malaysia began at the beginning of the nineteenth century when the inhabitants of the Straits Settlements (S.S) of Penang, Malacca, and Singapore were first separately counted in 1801, 1826, and 1824. The first modern population census in Malaysia was firstly established in 1871 and later in 1891 and 1901, and the enumeration was later expanded to Negeri Sembilan, Perak, Selangor and Pahang, in conjunction with the establishment of Federated

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*Corresponding Author

Malay States (F.M.S) under the British colonial government. The complete set of the population statistics for the whole Peninsular Malaysia was first made available in the year 1911. However, no census was undertaken during World War II. Two years later, i.e. in 1947, the census was continued. With the formation of Malaysia in 1963, the next census was held in 1970 and it covered the entire Peninsular Malaysia as well as Sarawak and Sabah (Saw, 2007). Thereafter, the national census was conducted decennially with the most recent one in 2008 (http://www.statistics.gov.my).

Since then, studies in economics, sociology, history, rural development, and agriculture have commonly used censuses (Lim, 1967; Wafa, 1972; Ooi, 1976; Hill, 1977; Abdullah, 1989a,b; Kato, 1991:1994; Rigg, 2003). Nevertheless, these studies mostly focus on the textual and numerical analysis of the census data without paying much attention to the sense of space of the censuses. In other words, census-related studies and literature in Malaysia thus far mostly present their results in tabular and graph formats. These studies do not use spatial representation and analysis, despite the fact that maps are suitable tools to visualize the numerical data (Campbell, 1993; Cartwright *et al*., 2007).

In recent years, as a spatial database management system (DBMS), the Geographic Information System (GIS) has developed powerful tools for visualizing data (Peters and MacDonald, 2004; Fisher and Unwin, 2005; Liao *et al*., 2010). This development naturally leads to the emergence of new sub-disciplines or interdisciplines and one of them is Historical GIS, in which the GIS provides the investigation tool to study past phenomena, including demographic patterns, changes in land use and geopolitical scenarios (Gregory and Ell, 2007; Knowles, 2008). Since Historical GIS in Malaysia is still relatively lacking, this study was conducted to apply GIS to visualize the population censuses in Peninsular Malaysia in the 20th century.

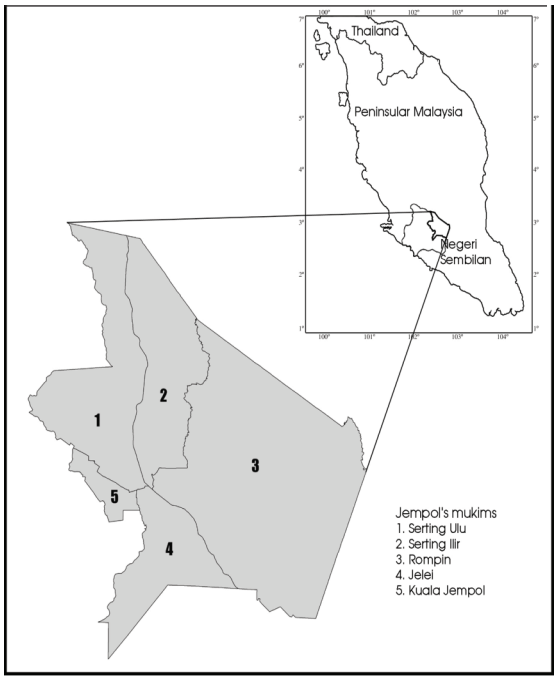

Fig. 1: Location of Jempol district, Negeri Sembilan, Peninsular Malaysia. Enlarged figure shows the five mukims in Jempol

MATERIALS AND METHODS

The district of Jempol in Negeri Sembilan was chosen as a case study since it contains several *mukims* (subdistricts) of different sizes and population densities. Jempol is located between the latitudes of 2°35′-3°10′ North and longitudes of 102°10′-102°45′ East (*Fig. 1*). It is the biggest out of the seven districts in Negeri Sembilan. The total land area of Jempol district is estimated to cover 138,569 ha, which is approximately 21 percent of the total land area of Negeri Sembilan. Prior to 1980, all the *mukims* of Jempol were under the administration of Kuala Pilah district office and Jempol only became an administrative and registration district on its own on the 1st of January 1980. Five *mukims* were gazetted, namely Kuala Jempol, Jelei, Serting Ilir, Serting Ulu, and Rompin. Among them, Rompin is the biggest whereas Kuala Jempol is the smallest *mukim*. According to the Jempol District and Land Office, there was no amendment in terms of a *mukim*'s extent during the demarcation of Jempol district in 1980 (Mat, 2008 pers. comm). Bahau, which is located within the Jelei mukim, is the capital town of the district. Jempol was dubbed as the '*Daerah Laluan Bersejarah' (*District of Historic Route) on 24th March 1998 as a token of appreciation to the historic site of *Penarikan* land portage (Ibrahim and Jamaludin, 1999; Wheatley, 1961).

This study was divided into three steps, as follows:

1. Exploring data availability
2. Establishing a base map
3. Conducting GIS analysis

Exploring Data Availability

The population censuses of Jempol were obtained from the Department of Statistics Malaysia (DoSM). While the intention was to go as far back as possible to investigate the demographic changes that took place in the district in the 20th century, this study found that the available censuses merely started from 1947. Much to the researchers' dismay, and as discussed by Fong (1983), the censuses and their raw data collected before the 1947 had been either misplaced or destroyed. In this study, the censuses of Kuala Pilah district according to its *mukims* from 1947 to 1970 were obtained in order to 'construct' Jempol within the periods of study since Jempol was under Kuala Pilah district prior to 1980.

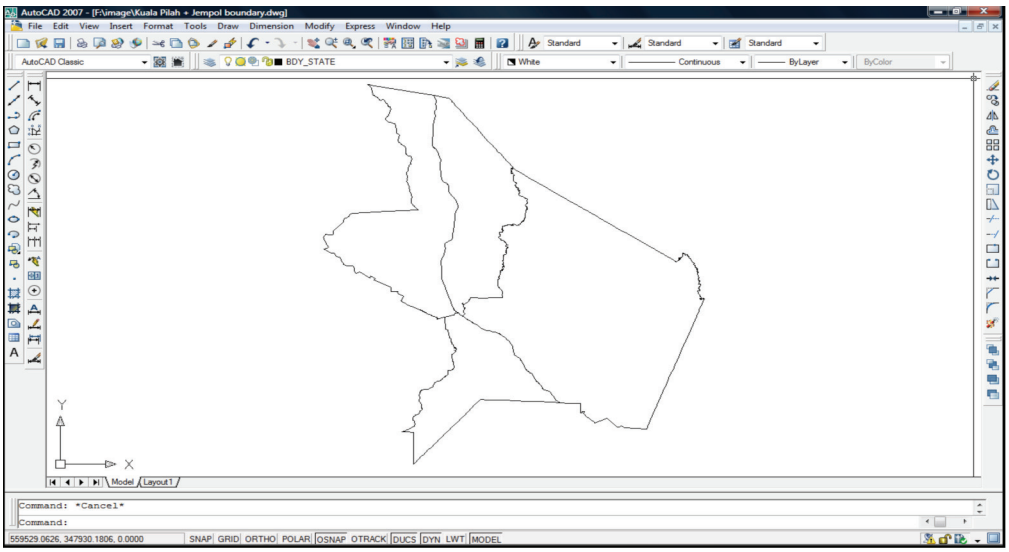

Fig. 2: 'Extracted' mukim's boundary of Jempol using AutoCAD 2007 (Modified from JUPEM, 2008)

Establishing a Base Map

In establishing a base map, two main steps were conducted in this study, and these are as follows:

Building up the mukim's boundary

The topographic digital maps of Jempol district were obtained from the Department of Survey and Mapping Malaysia (JUPEM). The maps are the compilation of georeferenced map sheets digitally published that were based on the aerial photographs taken in 1985. The boundary of the *mukims* within the maps was 'extracted' using AutoCAD 2007 (*Fig. 2*). The boundary was then exported into GIS. In GIS, polygons of the boundary of the *mukims* were constructed using EditTools 3.6 in ArcView 3.3.

Keying in censuses into GIS attributes

Since Jempol was in the district of Kuala Pilah prior to 1980, the censuses of Jempol before that particular year were derived by extracting the censuses of five *mukims* of Jempol, namely Kuala Jempol, Jelei, Serting Ilir, Serting Ulu, and Rompin, from the Kuala Pilah censuses (Table 1). Since there was no amendment in terms of the five *mukim*'s extent in demarcating Jempol district in 1980 (Mat, 2008 pers. comm), the extraction of the five *mukims* from Kuala Pilah censuses to 'construct' Jempol district before the 1980 is considered as acceptable in the present study. The censuses were then keyed in the GIS attributes using ArcView 3.3 (*Fig. 3*).

Conducting the GIS Analysis

In this study, two types of map, known as choropleth and cartogram, were constructed using GIS to conduct visualization analysis of the censuses.

Choropleth map

A choropleth map is 'a quantitative areal map in which the average magnitude of a phenomenon is indicated by a distinctive tone, pattern, or colour applied over each unit area. Unit areas are delimited by state or county boundaries, or other arbitrary boundary lines' (Campbell, 1993:

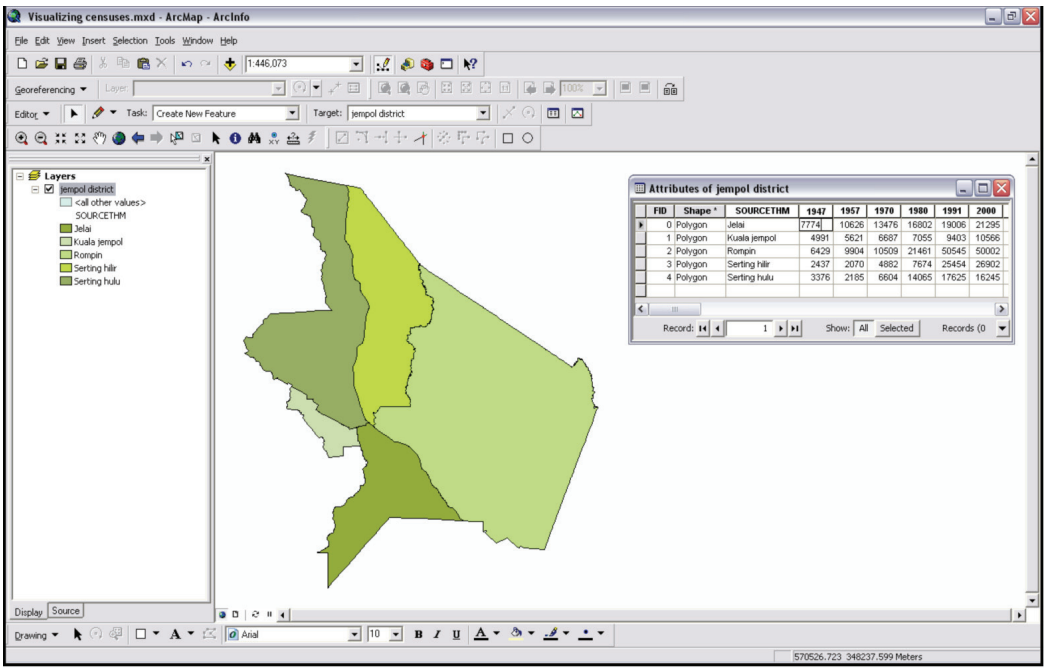

Fig. 3: Key in censuses into GIS attributes

TABLE 1
Total population in Jempol district based on its *mukims*, 1947-2000

Year	1947			1957			1970			1980			1991			2000		
Mukim	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Jelei	4603	3171	7774	5766	4860	10626	6751	6668	13419	8334	8468	16802	9416	9590	19006	10500	10795	21295
Kuala Jempol	2385	2606	4991	2631	2990	5621	3203	3498	6701	3447	3608	7055	4506	4897	9403	5105	5461	10566
Rompin	4030	2399	6429	5559	4345	9904	5543	5029	10572	10834	10627	21461	25771	24774	50545	25879	24123	50002
Serting Hilir	1363	1074	2437	1146	924	2070	2285	2210	4495	3832	3842	7674	13211	12243	25454	13578	13324	26902
Serting Ulu	1826	1550	3376	1058	1127	2185	3251	3238	6489	7080	6985	14065	8806	8819	17625	8046	8199	16245
TOTAL	14207	10800	25007	16160	14246	30406	21033	20643	41676	33527	33530	67057	61710	60323	122033	63108	61902	125010

Source : DoSM

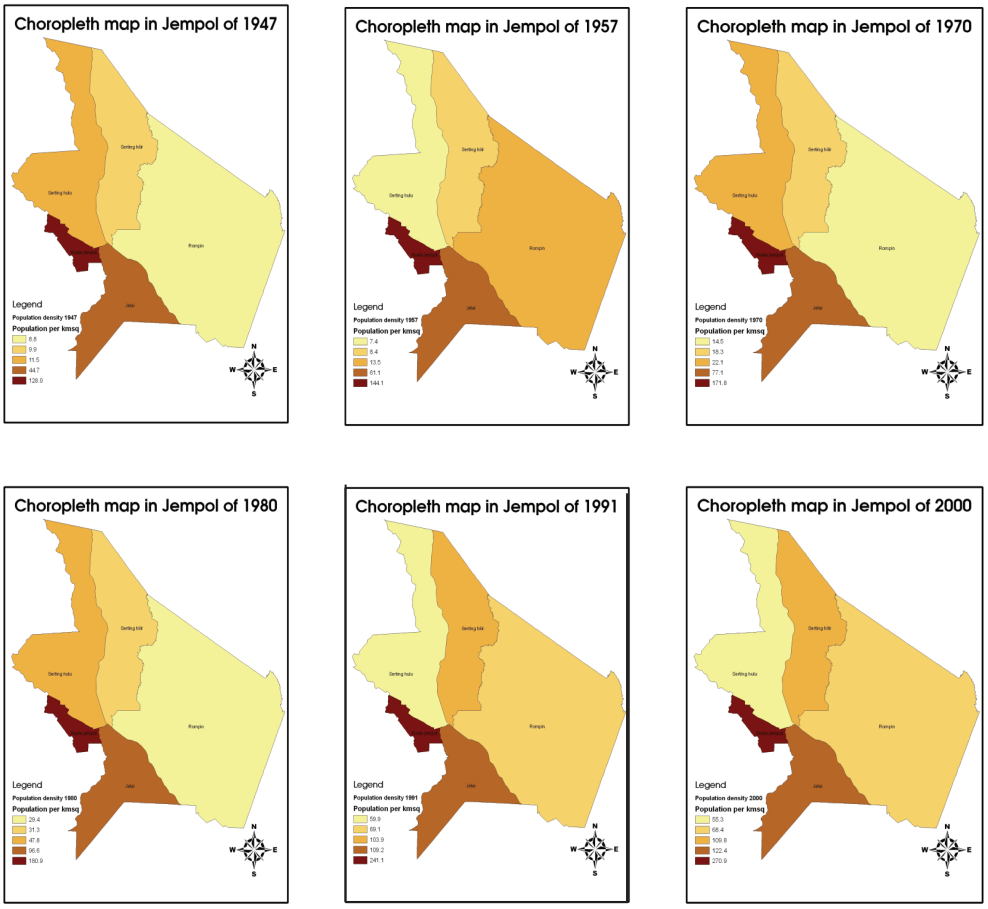

Fig. 4: The choropleth maps of population density, 1947 – 2000

400). The choropleth maps of population density according to the *mukims* in Jempol from 1947 to 2000 were generated using ArcView GIS 3.3 and ArcGIS 9.2. In producing the maps, three steps were followed:

1. An attribute data of areal size for each mukim was produced using XTools extension in ArcView GIS 3.3.

2. Using Field Calculator in ArcView GIS 3.3, the attribute data of population density based on the *mukims* in Jempol was constructed. Here, the population density is given by:

$$\text{Population density} = \frac{\text{Total population in a mukim}}{\text{Total area of mukim (km}^2\text{)}}$$

3. The population density was ranked and presented spatially in a choropleth map using ArcGIS 9.2.

Cartogram Map

A cartogram map is 'a special type of map, in which a different standard of measurement, such as time or cost, is substituted for distance measurement, or in which the area of regions is made proportional to some other measure, such as population or income' (Campbell, 1993, p.

399). There are two main types of cartograms, namely area and distance cartograms. In this study, the area cartogram maps for the *mukims* in Jempol from 1947 to 2000 were produced in ArcGIS 9.2. The maps were generated based on the Gastner-Newman method (Gastner and Newman, 2004). In constructing the maps, three steps were followed:

1. The query of population density for Jempol has been built in Definition Query of ArcGIS 9.2.
2. Using Cartogram toolbox of Gastner and Newman (2004), a geodatabase of population density was generated.
3. The population density cartogram map was made using ArcGIS 9.2.

RESULTS AND DISCUSSION

The choropleth maps (*Fig. 4*) clearly depict the population density changes in Jempol's *mukims* over the study period. The topology and shape of the *mukims* can be recognized quickly, particularly by someone who is familiar with the map of the study area. Since the data appearance of the population density on the choropleth maps was differentiated based on colour tones while remaining fixed in their geographic locations, the visualization is considered location orientated. This means if a coordinate of Kuala Jempol for instance is specifically located at coordinates (X_n, Y_n) with the total area of X km^2 in 1947, the location and its areal size remain the same until the year 2000. The only change is its colour tone appearance since the values of population density have changed over time. Therefore, the location and topology of each *mukim* are clearly visualized and consistent throughout the census years. However, a choropleth is only suitable in visualizing the censuses using different colour tones. If the maps are visualized using a single hue, the pattern and ranking of population density may disappear.

In contrast, the cartogram maps (*Fig. 5*) provide a different visual impact because the *mukims* appear to be expanding and shrinking according to the changes in the population density over time. It shows that Kuala Jempol has consistently become the biggest in term of size from other *mukims* for the past 53 years, especially in the year 1947, 1957, and 1970. Rompin was found to be otherwise, i.e. it had gradually become the smallest before increasing in size by the year 2000. These cartographic changes make it very easy to visualize the pattern and ranking of population density between the *mukims* throughout the census years, even by using colour tones or hues. Since the *mukims* area was cartographically modified according to their density values, the visualization of cartogram is considered space orientated. In

TABLE 2
Comparison between choropleths and contiguous cartograms of Gastner-Newman

Choropleth maps	Cartogram maps of Gastner-Newman
Kuala Jempol is the smallest in size	Kuala Jempol is the biggest in size
Rompin is the biggest in size	At first, Rompin is the smallest but gradually increasing in size
'Location orientated' because the *mukims* density were differentiated based on tone colours while remaining their geographic locations	'Space orientated' because the *mukims* area were cartographically modified according to their density values
Topology (connectivitiy between *mukims*) is maintained with retained areal sizes	Topology (connectivitiy between *mukims*) is maintained with unretained areal sizes
Pattern and ranking is visible but not clear	Pattern and ranking is visible and clear

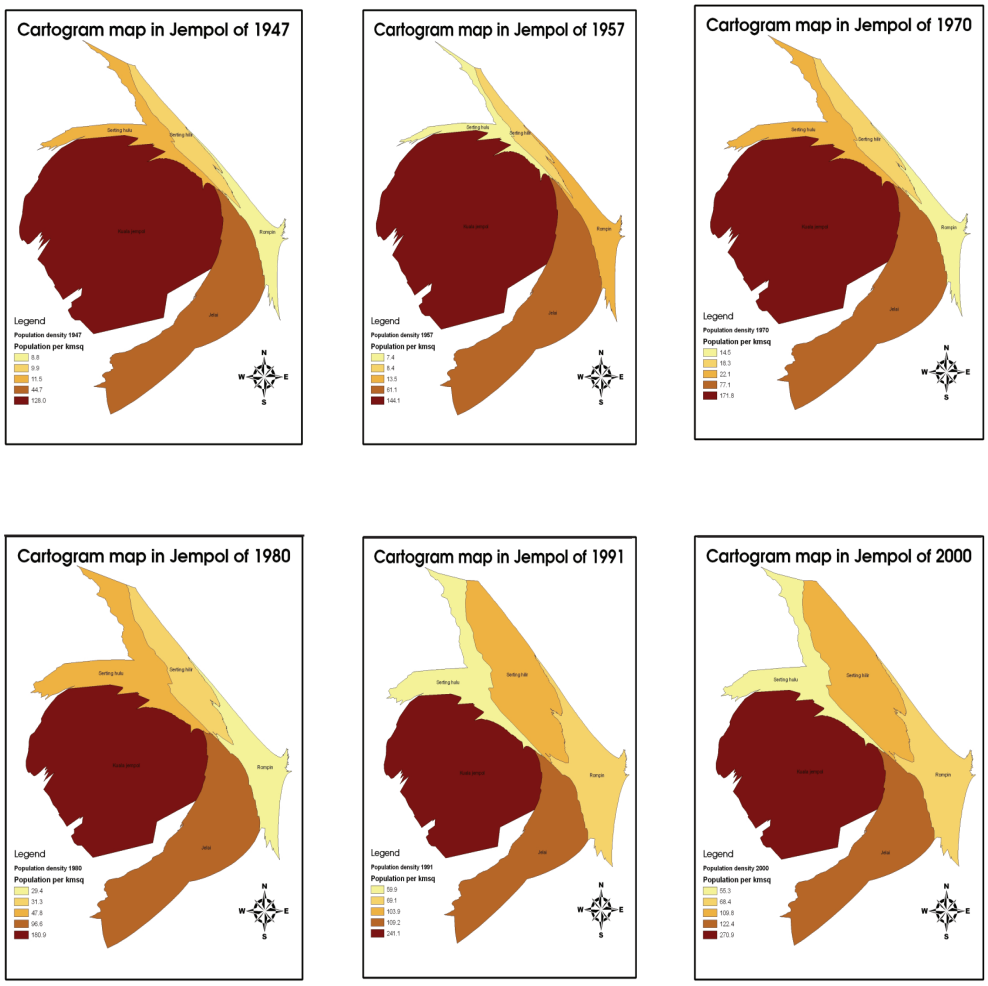

Fig. 5: The cartogram maps of population density, 1947 – 2000

other words, if a coordinate of Kuala Jempol for instance is specifically located at (X_n, Y_n) with the total area of X km^2 in 1947, the location and its spatial extent would be changing depending on the calculated density values throughout the census years.

The population patterns of Jempol in the 20th century can be classified into two different periods: (1) British colonial and (2) post-colonial or Independent Malaya. The colonial period covers the first two census years of 1947 and 1957. The British government conducted the last census in 1957 before the Federation of Malaya achieved its independence on 31st of August 1957 (Hasan and Kasim, 2007). At the time, Jempol was under Kuala Pilah district. As visualized on the choropleth maps, human population was found to be extremely concentrated in the south-western part of Jempol. The resettlement project of New Village due to the Emergency state in the mid-20th century was suggested to be the main cause for this particular demographic phenomenon. In Negeri Sembilan, two programmes known as 'Briggs Plan' and

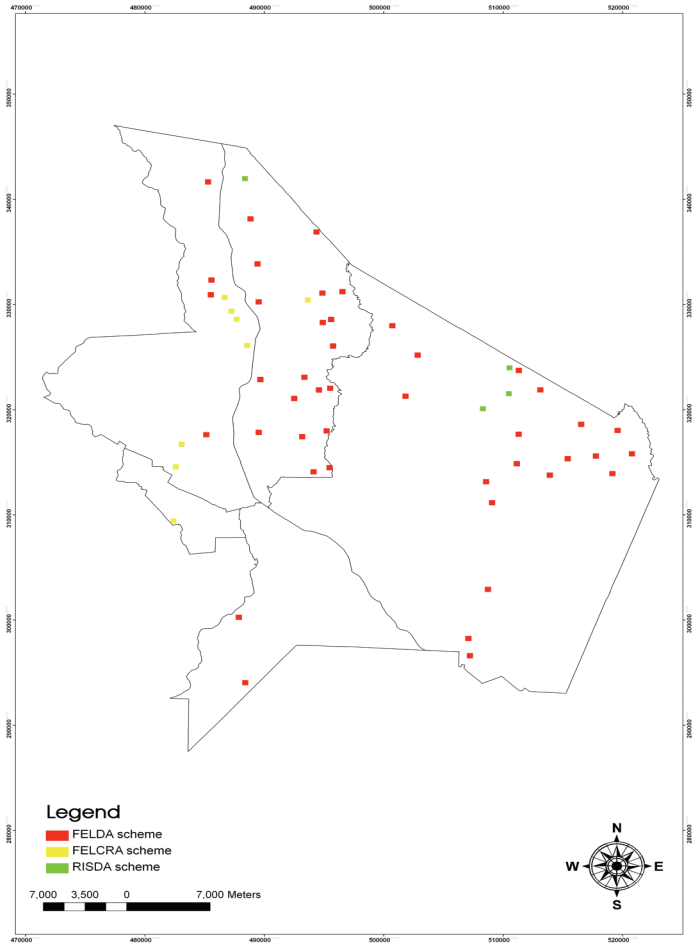

Fig. 6: Spatial distribution of land development schemes in Jempol during the post-colonial era
(Adapted from the JUPEM's topographic digital map, 2009)

'Central Rice Kitchen' were initiated (Dartford, 1958; Sheppard, 1965; Hack, 2001). Under the programmes, the families who were living in the remote area and were susceptible to the insurgent communist attacks were relocated into the new settlements which were tightly controlled by the government security forces (Ooi, 1976; Gullick, 2003; Saw, 2007). Within the Kuala Pilah district, there were three locations involved under the project, namely Simpang Pertang, Ulu Juasseh and Bukit Gelugor, which are situated in the south-western part of Jempol (Atlas Kebangsaan Malaysia, 1977).

The post-colonial period covered the census years of 1970, 1980, 1991, and 2000. After the independence, rural development was given a high priority by the new independent government. The main focus of the development had been on upgrading rural infrastructure as well as increasing agricultural productivity (King and Mohd. Jali, 1992). In Jempol, under the *Buku Merah* (Red Book) Rural Development Plan, an irrigation scheme was launched at Kampung Kuala Jempol in 1963 which aimed to develop wet paddy cultivation activities in the district. After Jempol was officially gazetted as a

registration district of Negeri Sembilan in 1980, more efforts were implemented by the local authority to develop Jempol as an important agro-industry hub (Mat, 2008 pers. comm). One of the efforts was opening up new land to be settled and cultivated with commercial crops, especially rubber and oil palm. Therefore, several land development schemes were organized in Jempol under the Federal Land Development Authority (FELDA) Scheme, Federal Land Consolidation and Rehabilitation Authority (FELCRA) Scheme and Rubber Industry Smallholders Development Association (RISDA) Scheme. The rural development projects affected demographic patterns in Jempol. The population concentration in the south-western part of Jempol started to decrease as a result of human migration to the land development schemes, which were mostly located in the north-eastern part of Jempol (*Fig. 6*.) (Hashim, 2006).

CONCLUSIONS

GIS is a reliable medium in visualizing as well as analyzing human population censuses. Its capability in directly linking the aspatial data (censuses) and spatial data (Jempol *mukims* vector map) allowed the censuses to be spatially visualized. This cartographic feature opens up new possibilities because 'maps are visual, immensely appealing, and can be rhetorically powerful' (Dodge and Perkins, 2008). Besides, it enhances the historiography of the demographic phenomenon in the study area. It is recommended that further research in this area, such as overlapping the spatial analysis with human land use, topographic elevations and socio-economic characteristics, as well as constructing linear and non-contiguous cartograms, be conducted. Besides enhancing the spatial analysis of the censuses, this research paves the way for the development of historical GIS studies in Malaysia.

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