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Full Length Research Paper

Factors affecting agricultural land use for vegetables production- a case study of the state of Selangor, Malaysia

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Economic transformation and growth had resulted into increased population and change in taste of the people of Selangor, Malaysia. Evidence shows that the people have graduated from the consumption of highly starchy food to the consumption of more proteinous food, fruits and vegetables. This changing taste will hitherto produce effects on the sizes of agricultural land use for production of different agricultural crops. A case of drivers of agricultural land use for vegetables production (ALUVP) is assessed in this study. ALUVP was compared with the potential driving variables at three different scales using Spatial Analyst 3.2 in an arcGIS 9.2 environments. Findings indicated that vegetables are found cultivated in mixed cropping systems with coconut, orchard, paddy, rubber, idle grass, whereas there were observed competition between vegetables production and oil palm, swamp/forest for land use. Factors such as maximum temperature, average temperature, slope, population density and soil series have inverse relations with ALUVP while distance to lake, major river, minor roads, road density, number of raining days, percentage urban residents have direct relationships with it (ALUVP). Drivers of ALUVP differ at different scales of analysis with the effects of accessibility becoming more pronounced at lower scales of analysis than at higher scale. With reference to competition for land use within and between agricultural sector and other more profitable non - agricultural sectors, it is unlikely that the government policy initiative of achieving self sufficiency in vegetables production by the year 2010 will be achieved.

Key words: Agricultural land use for vegetables production (ALUVP), changing taste, economic transformation and growth, mixed cropping and policy initiatives.

INTRODUCTION

The state of Selangor covers an area of about 8000 square kilometers and is located between latitudes 2.58 and 3.83°N and longitudes 101.17 and 102.00°E (Figures 1a and b). The climate of Selangor is governed by two monsoonal wind which originates from the north east between October to February and the south west from May to September. Climatically, the state has no distinct dry season. Average daily temperature ranges from 21 to 32°C and mean annual temperature is 26°C and the daily humidity level exceeds 80%. At the North – Eastern part of the state is a range of granite intrusion, having narrow valleys and steep crest and on the fringe of this range is a metamorphic zone with hilly to steep terrain and also a

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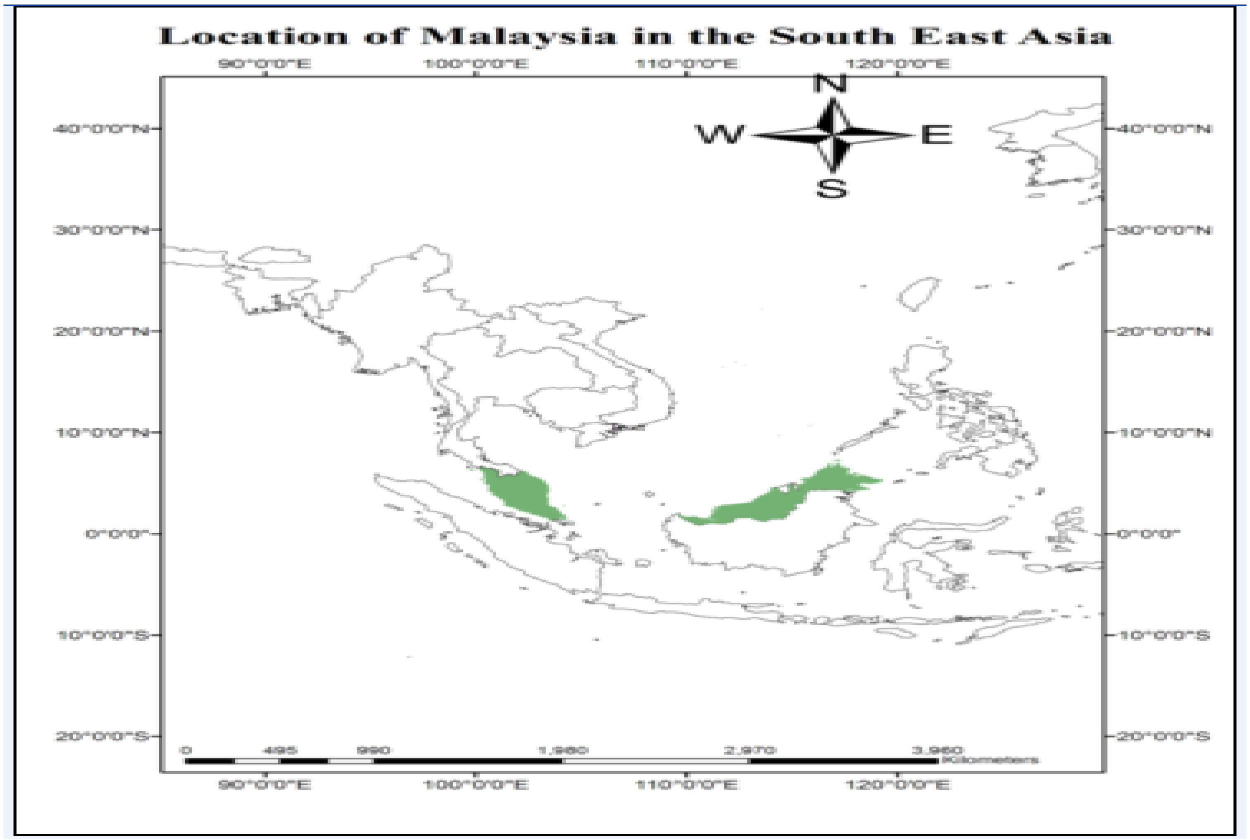

Figure 1a. Geographical location of Malaysia in relation to its Asian neighbours Source: EoN, 2010; Olaniyi et al., 2012.

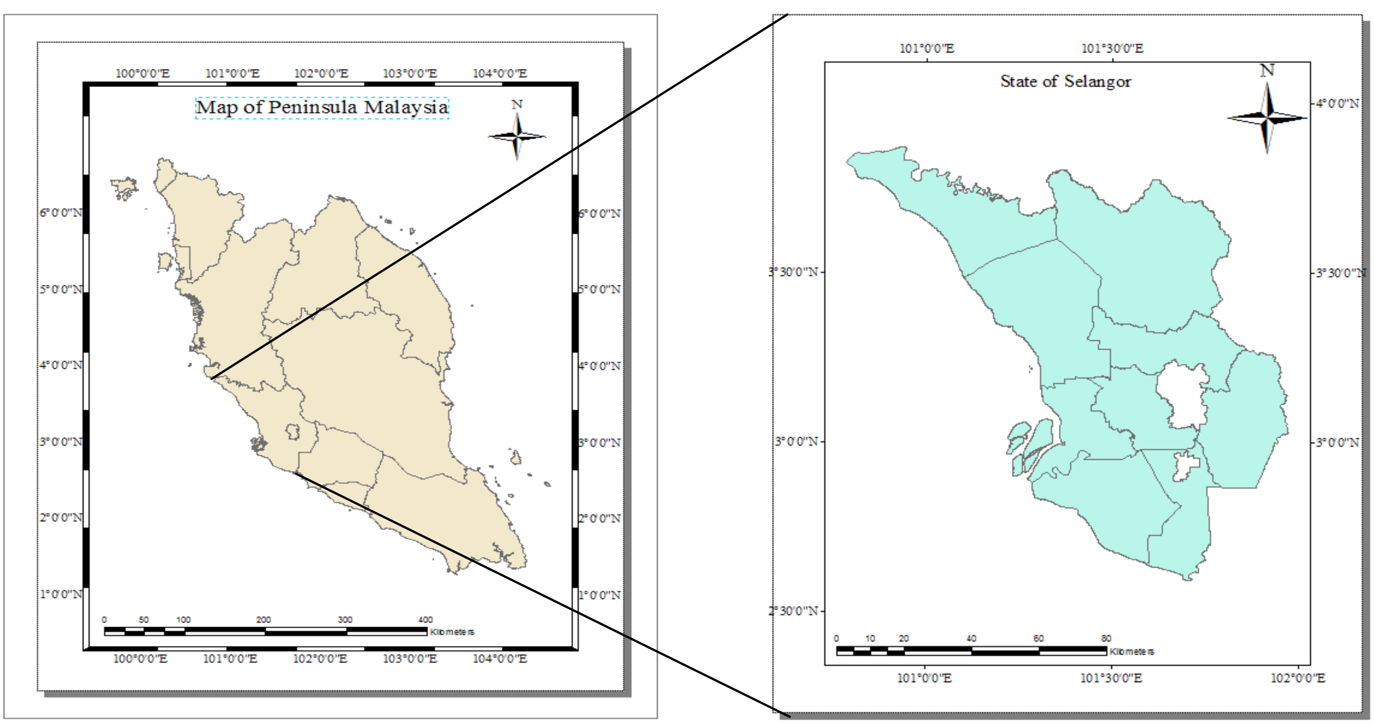

Figure 1b. Showing map of Peninsula Malaysia and the study area.

Table 1. Percentage change in Agricultural land use in Malaysia from 1985 to 2010.

Plant	85-90	90-95	95-00	00-05	05-10
Rubber	-1.2	-1.8	-1.5	-2.2	-3.2
Oil palm	6.5	4.6	4.3	2	1
Cocoa	6.6	-14.6	-3	-0.5	0
Paddy	0.8	-0.2	-5	-1.8	-1.1
Vegetables	2.1	3.7	2.7	5.7	6.2
Fruits	6.4	4.7	2.5	2.5	2.5

Source: Department of Statistics, Malaysia, 1999 estimates.

sedimentary zone with undulating topography and plain quaternary marine alluvia towards the state's boundary with a state called Melacca.

The state of Selangor is one of the most developed andin fact the richest state in Malaysia (Alias et al., 2010). For instance, the Malaysian Department of Statistics in 2010 found that the state single handedly contributed 22% to the national GDP. Selangor economy is primarily driven by the manufacturing and the services sector as these two sectors only contributed 33.2 and 61.3% to the state economy in 2009. UNDP asserted that the state has an adult literacy level of 95.1%.

This thus underscores the importance of the state in labour supply. The state houses the country's largest port (Port Klang) and the nation's largest industrial catalyst of economic growth especially the Kuala Lumpur International Airport and Subang Airport are found in the state (Alias et al., 2010).

Agricultural sector has contributed significantly to the economic development of the country as it used to be the major source of income, employment and foreign exchange earner (Alam et al., 2010).

However, from 1970 till date the contribution of agriculture to the economic development of the country dropped significantly from 22.9 to 18.7% and later to 13.6% in 1995.

Also the contributions of agriculture to employment fall from 39.7% in 1980 to 27.8% in 1990.

Comparatively, agricultural contribution to the GDP decreased from 8.8% in 2000 to 8.2% in 2005. Currently, agriculture is the third engine of growth next to manufacturing and service sectors (Alam et al., 2010).

However, agriculture still remains important in the production of food, vegetables and fruits for the teeming population (Table 1 and Figure 2). Currently, Malaysia farmers produce fruits and vegetable crops such as, banana, coconuts, durian, pineapple, rambutan and others (EoN, 2010).

Major vegetables and growing areas

Malaysia characteristics tropical climate is favorable for the production of fruits and vegetables EoN (2010). Vegetables productions have been found to be small-holder crops in Malaysia, with an average farm size of between 0.5 and 1.0 ha under agro forestry/mixed cropping system and low input technology. Important vegetable producing states in Peninsula Malaysia are Johor, Perak, Kelantan, and Pahang, and recently Selangor accounting for about 75% of the total vegetable production in Malaysia (Table 2).

Production

At the Peninsular Malaysia level, the agricultural areas gazette for vegetables had been increasing (Table 3) from 2000 till date and subsequently leading to production increase from 512,000tons to 717,000tons within that period worth of about MYR574 million or US$220 million. Fruit vegetables recorded the highest increase in both cultivated area and production with average yield between 15 and 18 t/ha (Table 4).

In Peninsula Malaysia, the annual per capita consumption of vegetables is 63.6 kg against the Food and Agriculture Organization (FAO, 1998) recommended 73 kg per capita per year (Table 5 and Figure 3). The growing demand for vegetables has been due to the rising population, higher per capita income, migration to urban areas, a greater awareness of health issues and an increase in tourism. In this context, this study concludes that demand for these products will continue to grow in the next few years (Table 6).

To take care of the shortfall between demand and supply, the country resulted to importation of vegetables. In 2005, the value of fresh vegetable imports reached EUR 324.37 million, 10.5% more than the previous year with major import partner being China, Australia, USA and Thailand. Despite the fact that Malaysia's vegetable industry has doubled its production over 10 years, its capacity is yet unable to meet the demand (Chong, 2007). However, availability of market has encouraged farmers in other states to embark on vegetable production.

The objective of this study is to identify in quantitative terms the factors affecting agricultural land use for vegetable production (ALUVP) with aims of finding whether land use constitutes potential impediment to the achievement of sustainable production of vegetables in the study area using logistic regression analysis.

Logistic models in land use and land use change analysis

The relationship between land use and its driving factors is a complex, dynamic and non – linear process that is usually accomplished by comparing land use and the

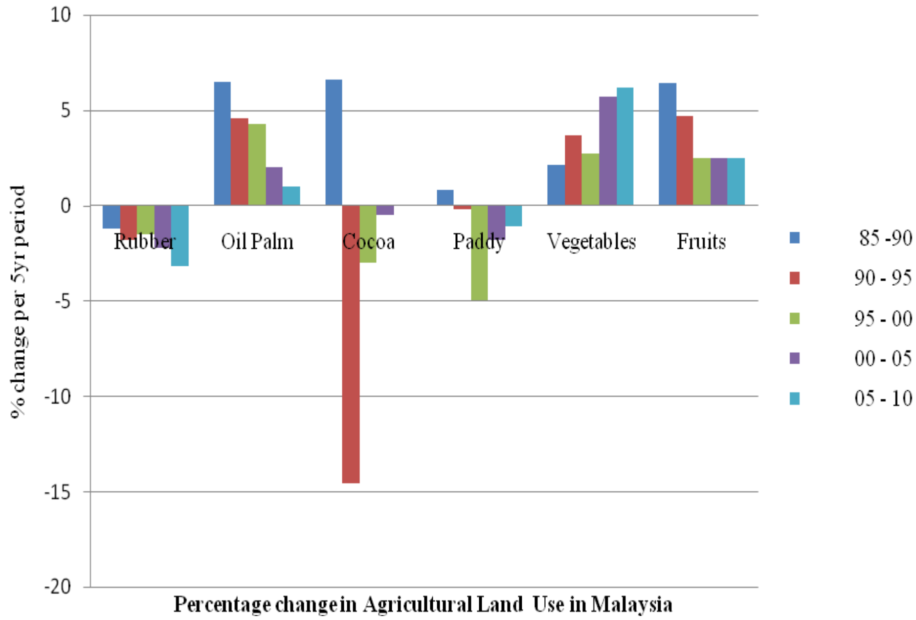

Figure 2. Change in agricultural land use for different crops.

Table 2. Planted areas of vegetables in Malaysia from 1998 to 2006 ('000 ha).

Planted areas('ha)	1998	2000	2003	2004	2005	2006
Vegetables	33	40	39	35	38	37
Cash crops	11	8	12	10	12	11
Spices	2	5	3	2	3	3
Total	47	53	54	47	53	51

Source: MDoA (2006b) quoted in Arshad et al. (2007).

Table 3. Showing the vegetable farm per states in Peninsula Malaysia.

State total	Area (ha)	Main vegetable growing district
Johor	16639	Johore Bharu, Muar, Kulang, Kota Tinggi, Batu Pahat
Pahang	5946	Cameron Highland, Rompin, Bentong
Kelantan	2756	Kota Bharu, Hulu Kelantan, Pasir Mas
Perak	2061	Batan Badam, Kinta, Kuala Kangsar
Selangor	1165	Hulu Selangor, Kuala Selangor, Kuala Lengung

Source: MDoA (2006a) quoted in Arshad et al. (2007); vegetables, spices and cash crops statistics, Malaysia, 2004. Kuala Lumpur.

Table 4. Yield of Vegetables in Malaysia from 1998 to 2006 ('000 tonnes).

Yield ('000 tonnes)	1998	2000	2003	2004	2005	2006
Vegetables	Na	405	547	587	547	560
Cash crops	Na	86	109	119	109	112
Spices	Na	21	24	20	26	45
Total	Na	512	680	725	682	717

Source: MDoA (2006b) quoted in Arshad et al. (2007).

Table 5. Per capita consumption of food commodities (kg/year).

Food commodity	1985	1990	1995	2000	2005	2010
Rice	102.2	89.8	86.9	85.7	82.8	80.4
Vegetables	42.4	45.5	48.5	52	57.5	63.6
Fruit	39.7	44.3	49.9	53.5	58.9	65.1
Beef	2.4	3.2	4.3	5.3	6.7	8.4
Mutton	0.4	0.4	0.6	0.6	0.7	0.7
Poultry	14.6	19	30	35.3	35.9	36.8
Eggs	11.4	15.7	16.4	16.8	17.2	17.3
Milk	37.2	37.7	51.5	53	56	60.6
Fish	33.4	34.8	39.1	49	53	56

Source: Department of Agriculture, Malaysia, 1999 estimates

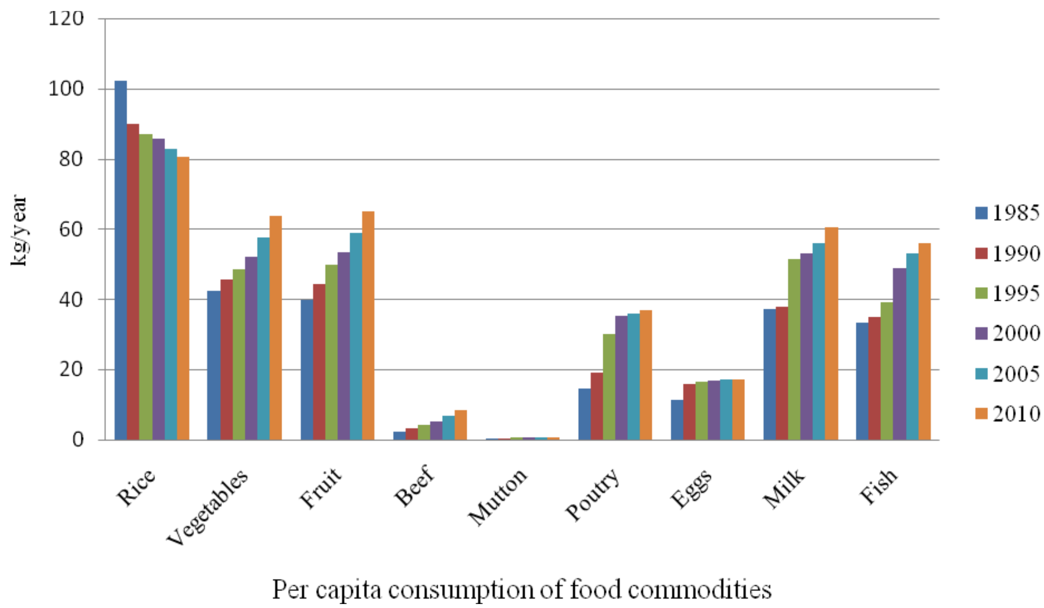

Figure 3. Showing per capita consumption of food commodities.

Table 6. External trades of Vegetables in Malaysia from 1998 to 2005 (RM '000).

Category	1998	2000	2003	2004	2005
Exports	205,934	278,411	393,734	462,785	504,497
Imports	986844	1,023,596	1,172,404	1,518,455	1,654,582
Trade Balance	-780,910	-745,185	-778,670	-1,055,670	-1,150,085

Source: MDoA (2006a) quoted in Arshad et al. (2007)

location specific characteristics at a polygon or pixel level (Karimi et al., 2010). These relationships have been successfully measured with the use of logistic models (Lesschen et al., 2005; Zhu et al., 2005; Zhang et al., 2010). This logistic regression (Equation 1) is used to predict the probability of the presence or absence of a particular (in our case ALUVP) land use type in relation with the driving factors of the land use.

$$\text{Logit}(Y) = \alpha + \beta_1 X_1 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \ldots \beta_k X_k \quad (1)$$

The coefficients (β's) of the logit model are the values for the respective driving factor for a particular land use type.

Values lower than 1 mean that the probability will decrease upon an increase in the value of the independent variables whereas, the values higher than 1 indicates an increase in the probability upon an increase in the value of the independent variables (Menard, 2001). While R^2 is usually used to describe the goodness of fit in ordinal least squares regression, the measure of goodness of fit in logistic regression can only be evaluated with the ROC method (Pontius and Schneider, 2001). Relative Operation Curve (ROC) is a measure of how well the model/independent variables correctly predict the value of the dependent variable. A ROC value higher than 0 .7 is considered acceptable in land use and land cover change modelling (Pontius and Schneider, 2001) while a value beyond 0.8 is considered excellent and value above 0.9 is considered outstanding (Homer and Lemeshow 2000).

Data

The 2006 state land use vector map used in this study was collected from the Malaysian Department of Agriculture (MDoA). Relevant biophysical data (soil, elevation, slope, minimum, maximum and average temperature) were obtained from the relevant government agencies while the socio–economic data were collected from the Malaysian Department of Statistics (MDoS, 2006). Elevation was included as a proxy for drainage that increases the cost of land development (Monmonier, 1982). Slope data as obtained from Malaysian Department of Survey was used as a proxy for suitability of a piece of land for agricultural purposes given the Malaysian edict that prohibits the use of land of slope greater than 15° for agriculture (MDoA, 1999). Several potential spatially explicit independent variables hypothesized to affect the dependent variables were also developed within a GIS. These include Euclidean distances to minor roads, lakes, water bodies, and major roads, population density, elevation, slope,aspect, and curvature. All variables were mapped at a resolution of 150 m; 200 m and 250 m to assess the effects of scales on factors affecting agricultural land use for vegetables production within arcGIS 9.2 software.

Derivation of GDP at district level

Some socio economic data (population and housing density) obtained from the Malaysian Department of Statistics (MDoS, 2006) were available at the district level whereas others such as (GDP were supplied at the state level. Therefore, to derive GDP at district level, some assumptions were made in order to simplify our study. For instance, the total age group between 15 to 64 per location (district) was assumed as the workforce of a particular location and the subsequent GDP were calculated based on the available workforce and the status (rural or urban) of that location. Therefore, manufacturing and services sectoral GDP were assumed to be contributed by labour in an urban areas and primary GDP was assumed to be contributed by workforce in the rural areas implying that mobility of labour were assumed to be restricted.

Derivation of population data

Population data for this study area were obtained from the Malaysian Department of Statistics. Data for the missing periods were derived using the method documented by (Braimoh and Onishi, 2007). This approach was used to derive population data of rural and urban residents of this study area in the year 2006.

Derivation of agro climatic variables

The main agro-climatic variables used in this study Table 7 are precipitation (number of raining day per annum) and temperature (minimum, average and maximum) (in °C) and these data were obtained from the Malaysian Meteorological Department and were converted to vector format using Spatial Analyst 3.2 in an arcGIS 9.2 environment. Per mapping unit pH and CEC were derived from global data set of derived soil properties (Batjes, 2000).

pH and CEC is a measure of the soil acidity or alkalinity of a soil otherwise called the soil "water" pH is a measure of the soil pH in soil solution, which is considered the active pH that affects plant growth. CEC is a value that is an estimate of the soils ability to attract, retain, and exchange cation elements. It is expressed in millequivalents per 100 g of soil (meq/100 g). Soil pH and CEC were selected because they (soil pH and CEC) have been considered the most functional soil property that is important in defining agricultural possibilities and constrains of a soil (Staal et al., 2002). Therefore, access to market and agricultural inputs were taken into account by the distance to transportation facilities (minor and major road, rail, and river) (Staal et al., 2002). Standard of living is determined by GDP per capita and this is used as a proxy for availability of market for vegetables.

METHODOLOGY

The methodology employed in this study involve the comparison of the land use type Agricultural land use for vegetables production (ALUVP) with the potential explanatory variables on a cell by cell basis (Karimi et al., 2010). Raster data of ALUVP and all the potential drivers were prepared using Spatial Analyst 3.2 in an arcGIS 9.2 environment (Figure 4). Land use map of this study area for year 2006 was obtained from the Malaysian Department of Agriculture. This map was reclassified to single out the area used for vegetable production. Data of slope, elevation and soil map

Table 7. Lists of potential drivers of ALUVP used in this study.

Soil variable	Biogeophysical variable	Demographic variable
		Total population
	Slope	Percentage rural population
Soil pH	Elevation	Percentage urban population
Soil CEC	Numbers of raining days	Rural work force
Soil suitability	Total amount of rain per year	Urban work force
Soil terrain	Average temperature	Total population density
Soil physical units	Minimum temperature	Distance to lake, main road, minor road, river
Soil series	Maximum temperature	Major road density,
		Major rail density,
		Minor road density,

were equally collected in vector format and were then rasterized.

Vector map of the potential socio-economic drivers such as population, population density, rural and urban work force, percentage rural and urban residents, primary, secondary and tertiary GDP maps were generated from the raw data obtained from the Malaysian Department of Statistics using arcGIS 9.2 and were thereafter rasterised.

Raw climatic data for the year 2006 were equally mapped into vector data and were subsequently rasterized. Rasterization of all vector data were done at the same spatial extent, geographical coordinates and three different scales in order to account for the effects of scales on drivers of agricultural land use for vegetables production ALUVP. The resulting raster data were all converted into ASCII files. A computer program was written to convert matrix - based m x n ASCII files into p x 1 vector data where p = m × n. The vector data were then imported into SPSS version 18 were logistic regression analysis was performed to identify and quantify the drivers of agricultural land use for vegetables production (ALUVP).

RESULTS AND DISCUSSION

The analysis were carried out at three scale such as 150; 200 and 250 m^2 so as to investigate the effects of spatial scale of analysis on drivers of agricultural land use for vegetable production (ALUVP).

These scales were chosen because it is related to the farm size maintained by every group of farmers in vegetables production (2.25; 4.0 and 6.25 ha). Since, vegetables are cultivated in mixed cropping systems with some crops such as paddy, coconut. The above spatial scale is considered as appropriate to represent farm size maintained.

Results in Table 8 clearly show the effect of three categories of driving factors on ALUVP viz: availability of suitable agricultural lands, biophysical factors and socio – economic factors.

Availability of suitable agricultural lands

ALUVP is observed to be competing for land use with other agricultural land uses such as oil palm cultivation, idle grass and swamp forest land uses (Olaniyi et al., 2011), whereas a level of mixed cropping is observed between ALUVP and other crops such as orchard, rubber, paddy and coconut this observation is in agreement with the report of (EoN, 2010). The practise of mixed cropping by farmers has both advantages of income security and higher productivity. However, where it is not properly managed, it could results to environmental degradation of the land resources and pollution of the aquatic environment as a result of excessive application of fertilizer on paddy fields (Chong, 2007).

It is noteworthy to observe from the result in Table 8 that at lower scale swamp forest showed a positive relationships with ALUVP, this is an indication that some vegetable are produced under agro forestry system while at a larger scale, ALUVP has negative relationships with swamp forest indicating total replacements of swamp forest by ALUVP and this has a serious environmental impact.

Biophysical variables

These include the effects of climatic and soil factors on ALUVP. From Table 8, it is observed that the following biophysical factor have negative effects on ALUVP, that is, maximum and average temperatures, slope and soil series whereas, elevation (a proxy for drainage), number of raining days and relative humidity have positive effects

Socio–economic variables

Factors such as dependency ratio (a proxy for availability of rural work force) distance to major river (a proxy for drainage); distance to minor road; minor road density (a proxy for access to farm inputs and information as well as market) and percentage urban population (a proxy for market access) have positive relationships with ALUVP while build up areas (a proxy for reduction in available land for vegetables cultivation), distance to lake (a proxy for access to irrigation water) and population density (a

Table 8. Agricultural land use for vegetables production and its driving factors using logistic model.

Parameter/scales	150 m	200 m	250 m
Constant	-6.310	-6.282	-11.999
Average temperature***	-	-	-0.591
Build up area*	-	-	-19.392
Dependency ratio***	-	-	0.747
Coconut***	0.948	.946	-
Distance to lake***	-0.534	-.0.527	-
Distance to major river***	0.270	0.264	-
Distance to minor road***	4.391	4.352	-
Elevation***	0.177	0.177	-
Forest land use****	-	-	-18.788
Idle grass***	0.336	0.333	-
Maximum temperature***	-	-	-1.094
Minor road density***	0.306	0.301	-
No of raining days/year***	-	-	1.018
Orchard land use***	0.716	0.497	-
Oil palm land use***	-	-	-2.052
Paddy land use***	1.978	1.984	-
Percentage urban**	-	-	0.08
Population density**	-	-	-0.101
Relative humidity***	-	-	0.82
Rubber field land use*	-	0.716	-
Slope***	-0.231	-0.229	-
Soil series***	-0.064	-0.064	-
Swamp forest*	0.480	-	-18.315
ROC	0.938	0.934	0.965

*, Insignificant; ** significant at 0.05; *** significant at 0.01.

proxy for poverty level and therefore poor market) have negative relationships with ALUVP.

From this result of logistic analysis presented on Table 8, the agricultural land use for coconut, orchard, paddy, rubber, idle grass have positive relationships with ALUVP. This shows that vegetables cultivation is found in mixed cropping with the mentioned crops. Whereas, land use for forestry, mangrove swamp build up area had negative relationship with ALUVP, this explains a form of competition between swamp/forests, build up and vegetables production for land use. Wherever, build up and vegetables are competing for land use, it implies a form of backyard farming and in most cases, these vegetable farms give ways to urban development. With this situation, it means that vegetable production will continue to put a lot of pressures on swamp/forest reserves and this has a lot of environmental implications.

This logit model helps to indicate which factors are important determinants of ALUVP in Selangor in 2006. The values of exp (β) values (odd ratio) for the logit model for each drivers of ALUVP in 2006 are shown in Tables 8. Values lower than 1 mean that the probability will decrease upon an increase in the value of the independent variables whereas, the values higher than 1 indicates an increase in the probability upon an increase in the value of the independent variables. Therefore all, except, two variables (distance to minor road and paddy field land use) will lead to decrease in the probability of ALUVP upon an increase in their values.

ROC is a measure of how well the independent variables correctly predict the value of the dependent variable. From Table 8, ROCs at all the three spatial scales of analysis ranges between 0.934 to 0.965 indicating that the independent variables were able to predict between 93.4 to 96.5% values of the dependent variable (ALUVP) correctly. At this level, the independent variables are assessed to have outstanding predictive power on the dependent variable (Hosmer and Lemeshow, 2000).

Conclusion

The Ninth Malaysian Plan, 9MP has set a national target

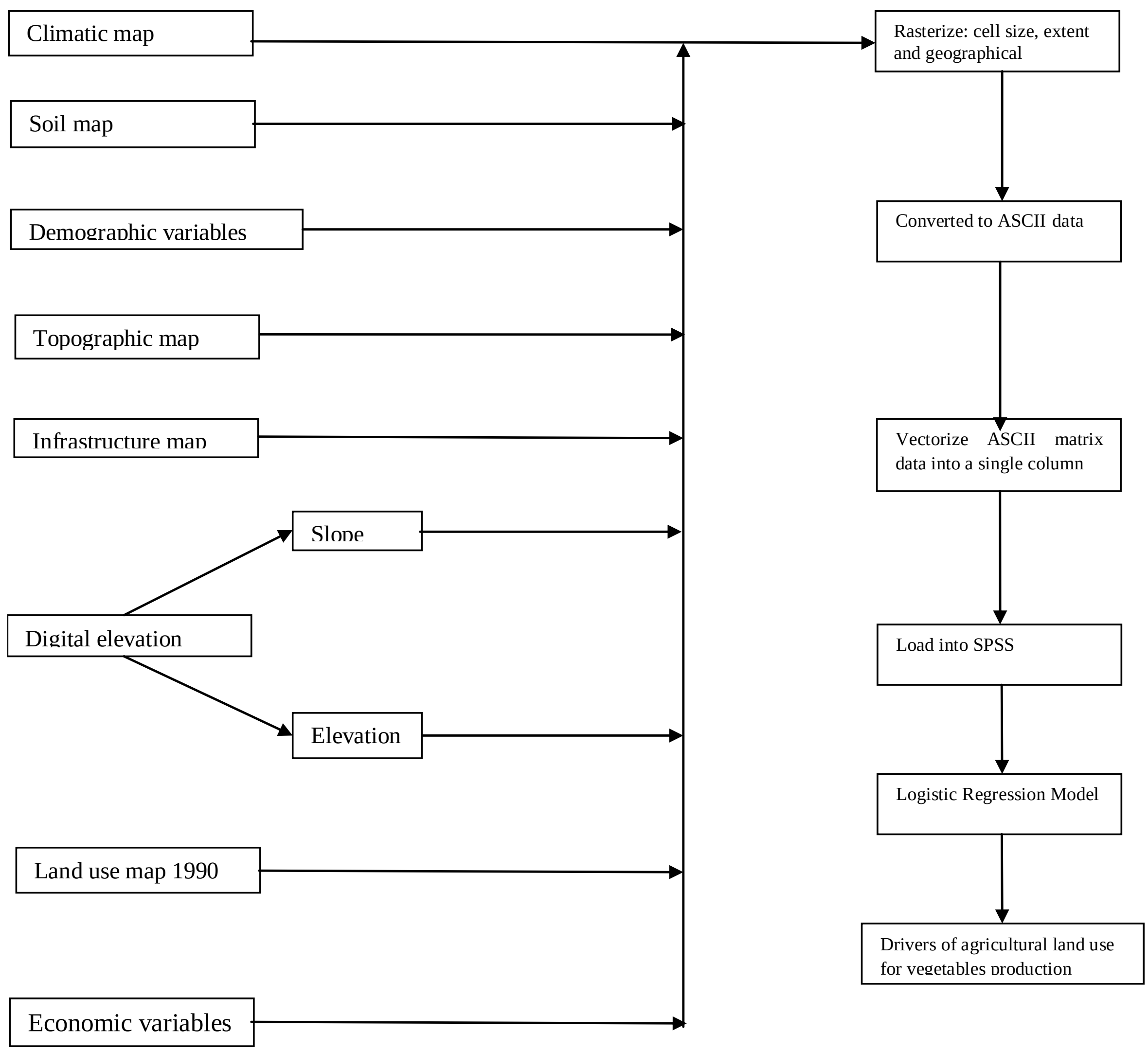

Figure 4. Diagramatic flowcharts of the research methodology.

for vegetable production to be achieved through the expansion of the cultivated areas by 6.1% (86,000 ha) thus substituting the importation by local production (Arshad, 2007). However, the occurrence of competition between ALUVP and other agricultural and non agricultural land uses is more likely to thwart achievement of the objectives of this policy initiative.

Therefore, yield improvement could be achieved from the current production areas through the use of improved varieties, effective pest and disease control perfect marketing and storage systems.

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