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Assessing the Dynamics of Urban Growth and Land Use Changes in Jeli Using Geospatial Technique

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Abstract

Land use change pattern in Jeli is been given a focus as part of tool for land planning and development. An increasing of population in Jeli make this study is relevant to aid an understanding on land use changes in this area due to the demanded for development and rapid land utilisation. Land use change pattern can be obtained via geospatial technique by Geographical Information System (GIS) together with satellite imagery analysis. In this study, land use maps produced from supervised classification using maximum likelihood algorithm give a high accuracy of 92.05%. From classified land use images, urban expansion index (SI) were then calculated from year 1984 to 2012. Pearson's correlation analysis discovered a strong negative correlation between forest and agricultural areas which reflected that with increased of agriculture area, forest reserve was found depleted. The SI of Jeli showed a low to rapid growth in 1994 and 1997 to 2012 respectively. The study reflected the progressive development in Jeli promotes sustainable usage of forest area when effort of reforestation was carried out forming a co-existence land use category between forest and agriculture.

1. INTRODUCTION

The process of organising, managing, and regulating the use of lands and their resources to meet the socio-economic development of a country such as Malaysia, is known as land use planning which is a vital tool in safeguarding the environment. The development of Jeli distict in Kelantan, progresses with year and increasing population demands for a strategic development by the State. The draft of Jeli's Local Plan 2020 (*Rancangan Tempatan Jeli* 2020) by Jeli District's Office outlined six thrust in the anticipated development namely progressive township development and sustainable suburban development, progressive economic development, holistic accessibility and transportation, improvement of community's quality of living, development and conservation of the environment, and finally excellent management and implementation of plans and policies by the state.

According to the land use data of Jeli in 2010, 59.81% of the total land use comprises of forest area which means that most of the land area in Jeli has not been explored or exploited for development purpose. The overall land use data recorded only 1.63% of the total land use is of built areas and 98.37% is of non-built areas. Therefore, the discovery of such abundance of natural resources hub in Jeli has triggered this study to be carried out to ensure that in the critical period of achieving Malaysia's vision 2020, natural resources are not being exploited adversely besides a consistent sustainable policy has been endorsed by the government to further protect this valuable public thrust.

The land use changes are often related to a few factors which include economic development, population density, political power and availability, etc. Therefore it is anticipated that land use in Jeli has shown a stable and progressive change over the years with a significant increase in urban areas. Second, rapid change in land use occurs at region with physical development of infrastructures and facilities such as road, learning institutions, hospitals, market, and housing area. Next, political influence, availability and support are the key contributor to progressive development of Jeli. Lastly, a stable increase in land use change for urban areas will take place in the future.

This study outlines two key problems which are (i) increasing population in Jeli has demanded for development and rapid land utilisation causing rapid land use changes, and (ii) rapid changes in land utilization has caused many negative impacts such as natural habitat destruction, flooding, human and wildlife conflicts. Based on the key problems outlined, this study is expected to be able to answer questions such as what is the most drastic and non-drastic change in land use since the establishment of Jeli? How rapid is the land changes in terms of urban

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growth? and could the application of geospatial technique such as remote sensing and GIS be helpful land use planning in Jeli?

This study will aid the understanding of land use changes in Jeli as well as be able to provide the first and latest statistical representation of data for tracking past and current land use in Jeli using the integration of remote sensing, existing land use maps and GIS. Besides, an urban land expansion index computed in this study will be a significant contribution in aiding local government and policy makers for land use planning in Jeli. This study could also provide an elaborate input on land use changes data so as the conflicts taking place so that local authority could formulate steps to mitigate the problems or harms incurred during the past years development. This will also open rooms for improvement and re-evaluation of the current physical plan of the region as well as a stringent implementation of law to protect the environment. The objectives of this study are o generate land use maps from 1984 to 2012 using the integration of remote sensing and GIS hence to analyse the land use changes in Jeli of the respective period.

2. LITERATURE REVIEW

Literature review about the study of land use changes using remote sensing and geographical information system (GIS) will discuss three main aspects which are the need for land use study, remote sensing and GIS and finally change detection techniques. Most of the literatures reviewed are related to utilisation of GIS in tracking land use changes in urban areas and forest areas from international countries and a few from local researchers and academicians.

The use of computer application such as GIS in the impact assessment can help produce a good decision and proper actions. The generation of environmental sensitive areas and high risk zones maps using GIS base modelling, for example, would very much help in planning decision making process (Yaakup et.al., 2000). According to Acevedo et.al. (1999) modelling future land use is based on historical land use patterns, together with current trends in a region. This model can be used by the public, land use planners, and policy makers to anticipate and plan for the future as well as generating alternative landscape predictions on the basis of different land use policies and environmental constraints.

A case study of land use changes analysis for Kelantan basin discovered that the main factor contributing to increasing magnitude of flooding in Kelantan was due to the local development or urbanisation that is closely related to population focus area, socioeconomic region, centre for state's office and administration, etc which contributes to soil erosion and sedimentation of river basins (Hussain & Ismail, 2011). Another case study in Klang Valley, Selangor assessed the urban development and landuse changes impact on the environment using GIS application. According to Yaakup et.al., (2000) a separate analysis conducted between 1988 and 1998 have shown an approximate of 20% green areas was lost and being converted to other land use, mainly for housing and industrial development. These areas include 14% of green areas allocated in the Structure Plan being developed mainly for housing to cater for the increase of population in Klang Valley Region. In addition, most of the land use conflict as compared to the Structure Plan involves housing (27%), industries (13%), recreation areas (7.8%), institutions (6.8%) and commercial areas (2.3%).

The change in demography from 2.07 million in 1980 to 3.7 million in 1997 was seen to be the main factor influencing the spread of urban growth especially the built up areas. Some of the most common factors contributing to land use changes are increase in population demography, legislation, government policies and plans, decisions of developers or transportation entrepreneurs, the nature of the land itself, availability of technology to develop the land, illegal logging and development, and personal choice. As such, the areas identified can be avoided from being developed. If development is a must however, these maps could act as guidelines to further justify the type of development to be implemented together with comprehensive procedures, standards and preventive measures embedded throughout the development activities (Yaakup et.al., 2000)

Another case study in the metropolitan Jilin City and its four districts from 1989 to 2005 concluded that the urban land increased nearly 94%. In the meantime, the population increased by 11.5%, GDP increased by 611.3%, and per capita GDP increased by 538% in the study areas thus proving that the economic growth drove the urban land expansion in metropolitan Jilin City. This finding correlates the idea of economic growth and expansion and differentiation of land use as well as the importance of sustainable revenue generating activities (Hu et.al., 2008).

A study of land use change in Britain by Bibby (2009) suggests that recent rates of change in land use have been slower than in the post-war period up to the 1970s. This contradicts the general public perception, often fostered by media accounts, of relentless expansion of urban areas into the countryside. The changes that have been taking place in recent years are much more complex than a simple shift from greenfield land to developed uses as towns and cities expand. This actually demands for a proactive adaptation and formulation of a tangible yet sustainable policy. The Government's policy in UK has been successful in focusing new developments on brownfield land and in cities and in achieving an increase in residential density. Thus, indicating the pattern of change is far more complex than is suggested by simple notions of urban sprawl.

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Remote sensing and Geographical Information System (GIS) is currently not a newly used tool to study the temporal and spatial land use changes in Malaysia (Yaakup et.al., 2000). Remote sensing is the term used to describe the collection of information without actually coming into contact with the area or object of interest (Johnson, 2005). In Malaysia, many studies have proofed that the importance use of geospatial technique especially using remote sensing and GIS in detecting land use changes and urban expansion. For example, rapid land use change was detected at the northern part of Gua Musang district where nearly 36% of the changes were associated land use conversions (Jusoff and Senthavy, 2003).

The advantages of remote sensing include the spatial, temporal, and spectral capabilities of the various remote sensing platforms (Johnson, 2005). Remote sensing also increases our ability to view the world as a single entity as well as numerous sections of the whole (Johnson, 2005). Large regions can be observed, or with the expanding capabilities, highly detailed images of an area can be viewed. Another benefit of remote sensing is the temporal advantage. The environment is constantly changing such as land features during the different seasons and in order to effectively monitor the changes, a technology is needed that can record the area or phenomenon in question within a matter of hours or days or over a period of several years or decades.

GIS is defined as an organised collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate, analyse, and display all forms of geographically referenced information, (Chandra & Ghosh, 2006). GIS also aids in several types of project such as land use and land cover mapping, urban growth studies, crop identification, ground water mapping, flood plain mapping, hydro morphological studies, wasteland mapping, district level planning and disaster management. Incorporating GIS technique in land use changes study helps to identify relevant factors contributing to such changes and the impact of such changes to environment, local polices and more (Yaakup et.al., 2000).

The main objective of change detection is to compare spatial representation of two points in time by controlling all variances caused by differences in variables that are not of interest and to measure changes caused by differences in the variables of interest (Lu et.al., 2004; Green et al. 1994). Algebra is the simple and straightforward method in detecting the changes that includes image differencing, image regression, image ratioing, vegetation index differencing, change vector analysis (CVA) and background subtraction.

Based on Lu et.al., 2004, image differencing subtracts the first date image from a second-date image, pixel by pixel while image regression establishes relationships between bi temporal images, then estimates pixel values of the second-date image by use of a regression function, subtracts the regressed image from the first-date image. Image differencing is said to be the simplest, straightforward and easy to interpret the results while image regression requires more focus to develop accurate regression functions for the selected bands before implementing change detection.

According to Radke et.al. (2005) a more sophisticated change detection algorithms result from exploiting the close relationships between nearby pixels both in space and time when an image sequence is available such as in spatial models. Spatial model incorporates a classical approach to change detection is to fit the intensity values of each block to a polynomial function of the pixel coordinates x.

3. MATERIALS AND METHODS

3.1. Study Site

Jeli (5.7007° N, 101.8432° E) is a district in Kelantan, Peninsular Malaysia with an area of 129,680.26 ha. The district comprises of the three sub-districts which are Batu Melintang, Jeli and Kuala Balah and is bordered by Thailand in the north, Tanah Merah to the east, Kuala Krai and Gua Musang to the south and the state of Perak to the west (Figure 1). It is a strategic location with huge potential for structured development in the future. Eighty percent of Jeli district is hilly or mountainous types. The district contains heavily forested area and with many river tributaries. The altitude ranges from 90 to 500 meters above sea level. The main rivers which run through the district are the Pergau, Renyut, Suda and Balah rivers.

3.2. Data collection and analysis

3.2.1 Satellite images

Landsat TM with different acquisition date from 1984 to 2012 were acquired from Malaysian Remote Sensing Agency. For this study, only images for year 1984, 1994, 1997, 2001, 2004, 2008 and 2012 were utilized based on the finest images with less cloud cover downloaded from open source website. Images were pre-processed using image enhancement and spatial filtering to produce improved images with contrast in brightness and enhancement (Faust, 1989). Geometric correction (GC) were performed on these images to level the satellite images to the earth's surface using ENVI 4.5 software. Region of interest (ROI) were selected and cloud masking were performed to enhance the visual output. Image classification was carried out using supervised classification to produce land use maps using ENVI 4.5 software. These maps were uploaded, georeferenced, projected to the WGS1984 coordinate system and digitised into shapefile (.shp) format in ArcGIS v10.2 (ESRI, California).

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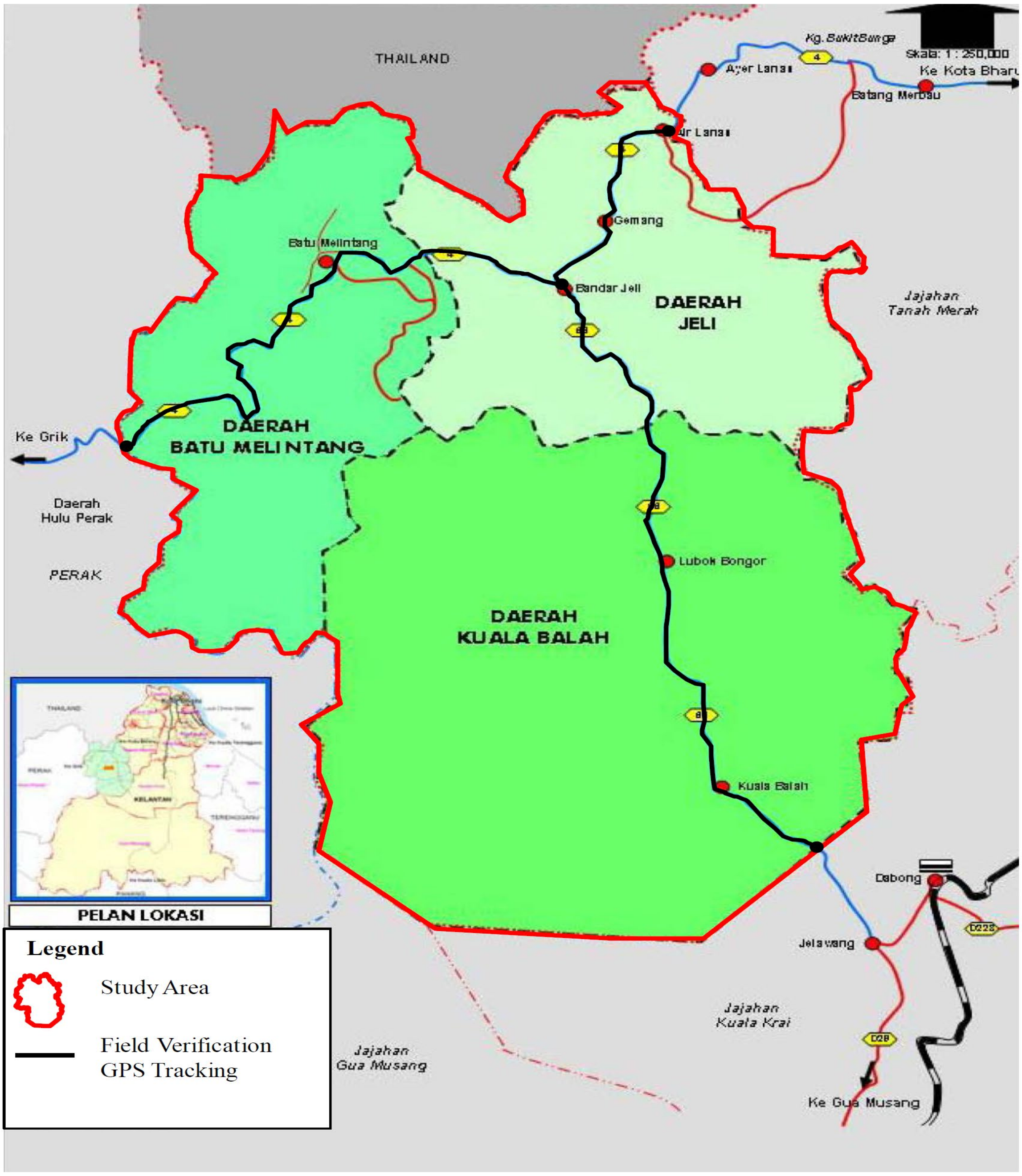

Figure 1: The Map of Study Area.

The accuracy of the maps spatial reference data is assessed using Error Matrix (Chandra & Ghosh, 2009) and calculated using Equation 1 below:

$$p = p' \pm \left[1.96\sqrt{\frac{(p')(q)}{n} + \frac{50}{n}}\right] \quad (1)$$

where,

p = overall accuracy at 95% confidence level
p' = the overall accuracy
q = 100 – q'
n = the sample size

3.2.2 Secondary data

Land Use and Land Cover (LULC) maps were provided by the Department of Agricultural Malaysia. These maps were uploaded, georeferenced, projected to the WGS1984 coordinate system and digitised into shapefile (.shp) format in ArcGIS v10.2 (ESRI, California).

3.3. Integrated Geographical Information System (GIS)

The digitised LULC maps in ArcGIS v10.2 was updated using information obtained from the ground truthing and visual interpretation works. Geo-referenced was carried out using GPS track data. The .shp data attributes were standardised and re-classified into ten land use categories which are urban, industrial, commercial, infrastructure & facilities, agriculture, recreational, forest, water bodies, road/highways and others. The size distribution of each map attributes in the .shp was set to areas in hectares.

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Data attribute was exported to Microsoft excel format (Microsoft, United States) for statistical analysis. The summary of process and procedure implemented in this study as presented in Figure 2.

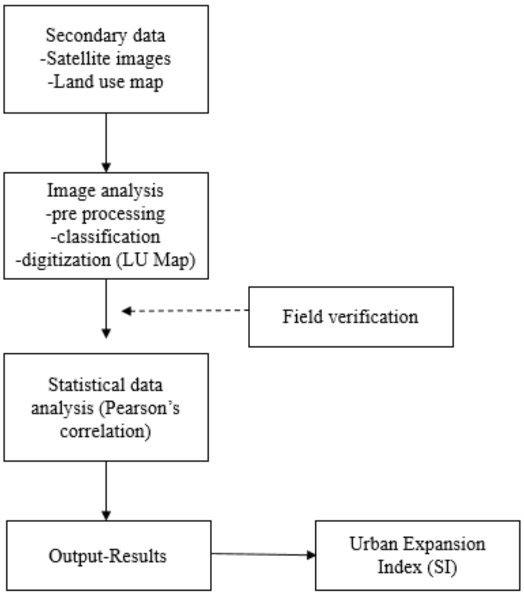

Figure 2: Materials used and methods implemented in this study

3.4 Land Use Change

The land use type percentage (PLU) of each category was calculated as the percentage proportion of the size of land use type area over the total land area in hectare as shown in Equation 2 (2). The percentage of changes (PC) of land use type between the years was calculated using Equation 3 (3). The mathematical formula for both Eq. 2 and Eq. 3 are as follows:

$$PLU = \frac{LU}{TL} X\ 100\% \qquad (2)$$

where,
PLU is the land use type percentage (%)
LU is land use type area (Ha)
TL is the total land area (Ha)

$$PC = \frac{LU_{t2} - LU_{t1}}{TL_{t1}} X\ 100\% \qquad (3)$$

where,
PC is the land use change percentage (%)
LU_{t1} is land use type area of previous year (Ha)
LU_{t2} is land use type area of later year (Ha)
TL_{t1} is the total land area previous year (Ha)

3.5. Urban Land Expansion Index (SI)

The Urban Land Expansion Index (SI) by David (2003) is used to characterise the growth of urban areas in the studied area. Table 1 show the description of SI index which has been applied to this study.

In order to get the SI value for the study area, it was is calculated using Equation 4 (4) as follows:

$$SI = \frac{UL_j + UL_i}{TL} X\ 100\% \qquad (4)$$

where,
SI is the urban land expansion index of a cell from period i to j,
UL_j is urban land area in period j (Ha),
UL_i is urban land area in period i (Ha)

Table 1: SI range and description

SI range (%)	Description
< 0.001	no change
0.001 – 0.1	low growth
0.1 – 1.0	rapid growth
1.0 – 5.0	more rapid growth
> 5.0	dramatic growth

4. RESULT AND DISCUSSION

4.1 Land use changes from 1984 to 2012

Land use maps were produced from image analysis using image classifier. Supervised classification using maximum likelihood (MLC) algorithm was selected to generate several land use classes. The output of image classification as shown in Figure 3. Accuracy assessment was conducted to determine the level of precision of the maximum likelihood supervised classification using Error Matrix. This assessment identifies overall error as well as the misclassification for each category. Overall accuracy gained from this classification was 92.04% with kappa statistic value of 0.91. Table 2 showed the percentage of land use changes detected from images from 1984 to 2012. From the result, an increase of urbanization was clearly detected within 28 years of analysis. Figure 4 showed the constant inclining of urban area in Jeli district. It is also seen that an increase of 20% from 121,941 ha of Jeli district area was converted to agriculture land. Increasing number of populations had influence the expansion of agriculture area in the district.

Despite of increasing number of several land use types detected from this analysis, forest area and infrastructure and utilities showed decrease patterns. With initial area of 120,653 ha in 1984, this type of land use had decrease to 84,827 ha in 2012. Forest area shrink yearly due to many reasons. One of the main reason was due to harvesting and timber extraction for national economic generation. Other forest activities that could reduce the forest area such as opening forest area for agriculture purposes and conversion of forest area to forest plantation area which has been introduced and started in Kelantan in 2000 for Timber Latex Clone (TLC) plantation.

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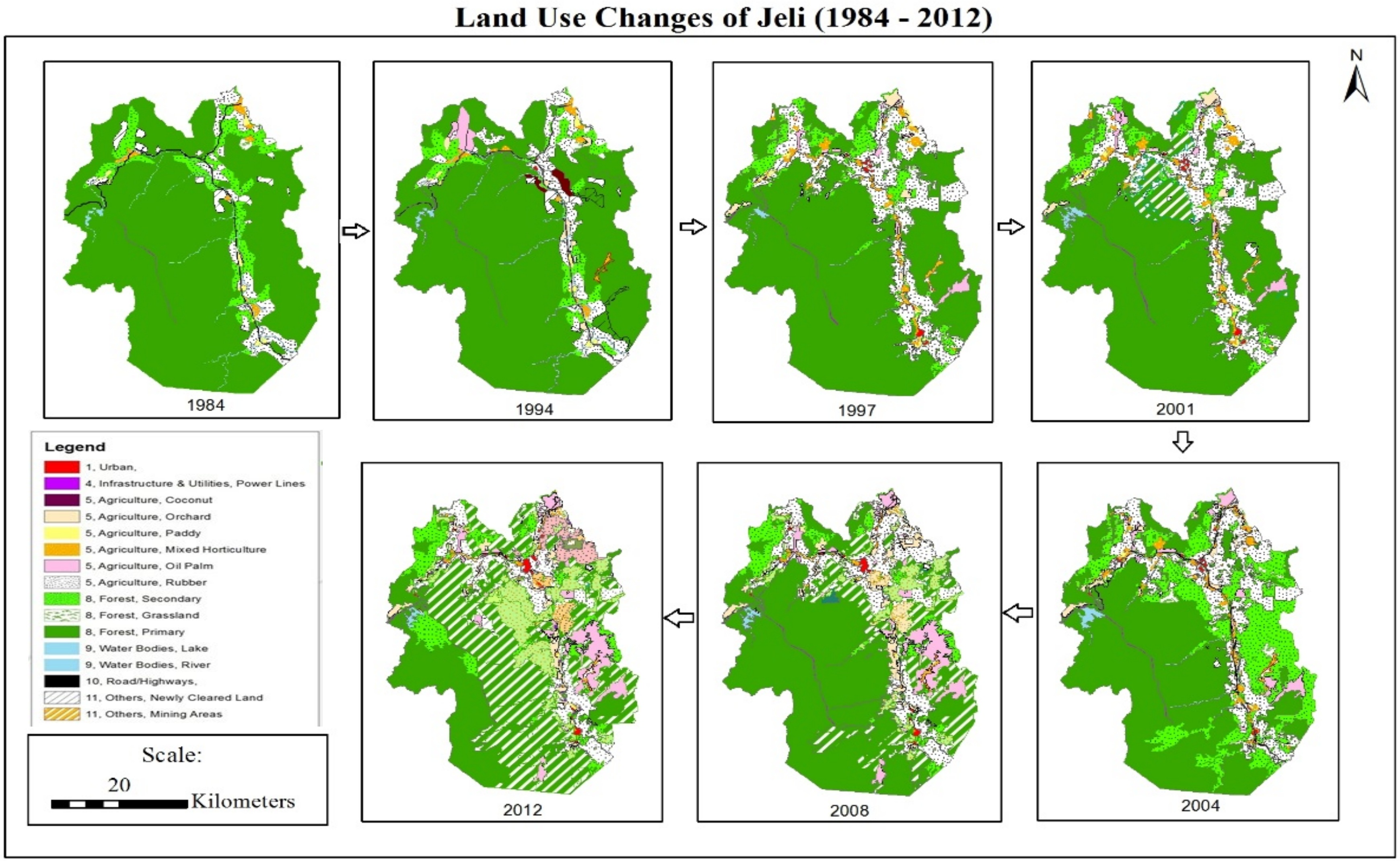

Figure 3: Image classification for land use changes of Jeli (1984 - 2004)

Table 2: Summary of surface and groundwater quality in the research area.

Land use type / Year	1984	1994	1997	2001	2004	2008	2012
Urban	0.00	0.04	0.27	0.28	0.35	0.43	0.57
Agriculture	6.83	12.0	20.5	20.7	20.7	25.8	27.0
Forest	89.3	83.8	77.4	76.8	76.0	71.6	69.6
Infrastructure & Utilities	0.10	0.10	0.26	0.27	0.29	0.37	0.39
Water Bodies	1.06	1.07	0.82	1.01	1.29	1.14	1.20
Road/ Highway	0.94	0.94	0.21	0.21	1.00	0.15	0.15
Other	1.77	2.10	0.60	0.84	0.41	0.58	1.09

Relationship between land use classes was tested using Pearson correlation. It showed that forest area has a significant strong negative correlation with urban, agriculture, infrastructure and water. This condition reflects that with decreasing in forest area showed a positive increment in the associated categories. However, there is a positive correlation between agriculture, urban areas and infrastructure and agricultural proving that with increase in agricultural area the associated categories also increases. This situation reflects that with increase in socioeconomic activity rate of land use changes also increase stimulating other categories to also develop when there is demand for improve facilities, water and power supply and more.

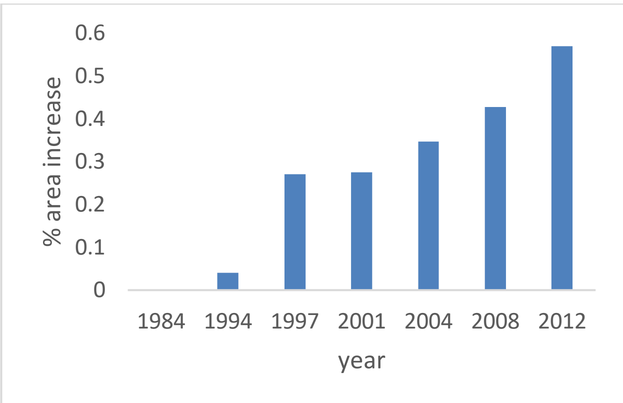

Figure 4: The urban area expansion of Jeli district observed from 1984 until 2012

4.2 Urban Expansion Index (SI)

Since the urban areas showed a positive increment throughout 1984 to 2012, urban growth was calculated to quantify the expansion index and describe the change that is taking place. According to an algorithm developed by David (2003), the SI or urban land expansion index was quantified and the results is as shown in Table 3.

The result showed that the SI value for urban land areas in Jeli falls under the range of 0.04 to 0.92. In general, Jeli district went through a low to rapid growth in 1994 and 1997 to 2012 respectively. Since no urban area detected in 1984, low growth value index was found in 1994. However, this situation give an expected changes and improved to rapid growth from 1997 to 2012 when SI value ranged from 0.31 to 0.92 respectively. The process of urbanisation affects all sizes of settlements. It includes, villages gradually grow to become small towns, smaller towns become larger towns, and large towns become cities. In this case, Jeli district showed a positive change of urban growth by years. Factor influencing this situation might due to increasing in population, agriculture area expansion for highly economical crops plantation such as oil palm and rubber consistently grow over the years which it also give job opportunity to the community.

Table 3: Urban land expansion index (1984 to 2012) of Jeli

Year	SI
1994	0.04
1997	0.31
2001	0.55
2004	0.62
2008	0.75
2012	0.92

5. CONCLUSION

It is learned that Jeli is still rich in forest area over these years even though the number decreases from year to year where it is consistent with the expected results of this study through the research questions and problems. This could be suggested another further investigation based on survey study to see whether this urban growth is likely to become more common in the future as a progressive development in Jeli. Through this further research one could promote sustainable usage of forest area due to the rapid urban growth of Jeli in the future.

The virgin or primary forest in Jeli has decreased drastically over the years with an increase in other forms of land utilisation primarily agriculture. Highly economical crops plantation such as oil palm and rubber consistently grow over the years. This changes in land use pattern portrayed that the socioeconomic activity in Jeli is primarily agriculture. Urban areas in Jeli also started growing in 1997, when a new political party took over the administration. Implementation of a new policy *'Developing with Islam'* focuses on improving the public demands but at the same time ensures the socioeconomic activity is safeguard as it is vital for Jeli and the nation.

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