Spatial Modeling for University Campus Planning.

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Abstract: Like many large communities in rapidly developing areas, Khon Kaen University campus, Thailand, has been faced with the problem of managing its land use. The demand for space for individual activities has risen as a result of the increase in the number of students and university staff. Issues of usage of infrastructures and buildings have grown beyond the physical plan of the university that was set up in 1979. The objective of this study was to establish a spatial modeling to support campus planning. A spatial infrastructure database which included such things as electricity, water supply and fiber optic cables from the concerned organizations was established to support land use planning and to be used as diagnostic factors for spatial modeling. Aerial photos taken in 1967,1976,1992,1997 and the Quick Bird Satellite imagery taken in 2004 were used to study spatial distribution patterns and landuse change in relation to the physical plan. The spatial modelings of the academic, administrative and residential zones were digitally performed through a weighting method for guiding an alterative physical plan of the campus. The result from the spatial infrastructural database can help to reduce the redundancy of all concerned data and also the spatial modelings for particular zones will be the helpful supporting data for best campus planning in the future.
Keywords: campus planning, spatial modeling.

1.INTRODUCTION

A university is a place of higher education that demands much of its students and staff. To facilitate these demands a university campus must be well planed and organized. A university must use its land and facilities wisely. This planning needs to be based on many factors(data) and future needs. Khon Kaen University (KKU) was the first university built in Northeast Thailand, established in 1964, for the purpose of developing agricultural studied and science. Issues of infrastructure and buildings had been growing over time so a physical plan for the university was set up in 1979 to manage land use. The concept of the physical plan was to put areas of study and services in the center while outer rings consisted of supporting facilities, housing and recreational zones. The whole surrounded by agricultural field and reserved area respectively (Dober, 1968). The original physical plan was to accommodate a university population of 15,000, but today the campus population is about 36,000. So the management of land use, buildings and infrastructure on the campus has faced many difficulties and the physical plan needs to be adjusted to be more suitable. One obstacle to the development of a new physical plan are that information (data) is widely scattered, out of date, difficult to retrieve, incorrect and not in digitally form.

A solution to this problem would be to use remotely sensed data and the capability in data integration and analysis in Geographic Information System (GIS) to provide the support data need for making land use planning more efficient. Land use planning using GIS has been applied in several environmental management problems and urban planning in the past (Michael, 1996; Pete et al, 1993; Guisseppi et al, 1996). A land capability study using weighting factors and computations of land capability values is one of the analyzing methods which can be used for analyzing the demand of land for particular purpose.

2.OBJECTIVE

The objectives of the study were;

2.1 To establish the spatial database of infrastructures.
2.2 To study the land use change pattern in the campus.
2.3 To create a spatial modeling of academic, administrative and residential zones to serve the development of the university.

3.STUDY AREA

The study area was Khon Kaen university campus which is located in Khon Kaen Province, Northeastern Thailand with a campus area of 9.14 km^2. The study area is shown in figure1.

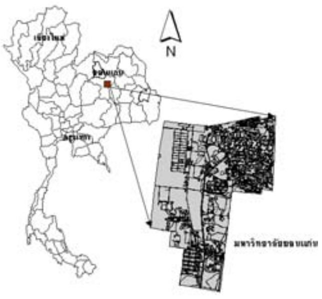

Fig. 1: The location of Khon Kaen University. KKU

4. METHODOLOGY

4.1 The establishment of an Infrastructure database.

There are 3 steps to establish infrastructures database included;

1) Data collection

The sources for establishment of infrastructures database are listed in table 1.

Table1.Spatial data set layer and its sources.

Layer	**data sources type**	**scale**
1.landuse 2004	- Pan-sharpen Quickbird Imagery acquired in January 2004 - field check by GPS - Attribute data of buildings from Planning Division	
2.Physical plan	chart of physical plan from Planning Division, KKU. 1996	1:50000
2.Electricity lines and transformers point	chart of electricity line from Planning Division, KKU.1996	1:50000
3.Raw water pipeline	chart of the pipeline of raw water from Planning Division, KKU.1996	1:50000
4.Sewage water pipeline	chart of the pipeline of sewage water from Planning Division, KKU.1996	1:50000
5.Main water Pipeline	chart of the pipeline of main water from Planning Division, KKU.1996	1:50000
6.Fiber optic phase I,II	chart of the fiber optic cable from Computer Center, KKU.1996	1:50000
7.Elevation	Chart of contour lines. 1969	1:50000

2) Create spatial data

The Quickbird Image taken in 2004 was used to determined land use in the campus area and to be used as a base map. The image processing steps were applied to the image included simplified radiometric calibration and geometric correction. The image was rectified into the coordinate system in UTM ZONE 47 and using Ground control points (GCPs) from GPS to increase the accuracy of the map. The visual image interpretation technique was used to classify land use type. Then, a spatial database and its attribute were created.

Infrastructure data was all stored in hard copy, so it was digitally encoded into GIS referencing with the land use map. In addition, its attribute data was linked together and it was stored in a database management system for easy to retrieve and update. To minimize error from input data, these infrastructure maps were plot and sent back to the concerned divisions for checking. Digital Elevation Model (DEM) was performed from contour lines to study the altitude of the study area.

4.2 land use change pattern in the campus.

This studies aim is to analyze land use change patterns in the campus since the university was established in 1964, the study years were 1967, 1976, 1992, 1997 and 2004. Aerial photos and Satellite imagery used in this study are listed below;

- Aerial photos taken in 1967 scale 1:50,000 , 2 photos
- Aerial photos taken in 1976 scale 1:15,000 , 10 photos
- Aerial photos taken in 1992 scale 1:6,000 , 25 photos
- Aerial photos taken in 1997 scale 1:15,000 , 10 photos
- Quickbird pan-sharpen image taken in January 2004 resolution 61 cm.

Aerial photos have been prepared by selecting the photos that in the study area and scanning into digital form. Geometric corrections for aerial photos were done by using a land use map of year 2004 as a base map for coordinate system referencing. In order to rectified images, GCPs from aerial photos were collected then an image to image technique was applied for Coordinate transformation. The nearest neighbor resampling method was then selected for resampling the pixels in aerial photos to fill in the rectified pixels. Finally, the geocoded images were mosaiced and enhanced for visual interpretation.

Landuse change analysis from year 1967-1976, 1976-1992, 1992-1997 and 1997-2004 was done by overlay operation in GIS. In addition, the analysis of landuse changes after the physical plan was set up was done by overlay landuse map in 1992 and 1997 with physical plan map.

4.3 A spatial modeling of academic, administrative and residential zones.

These particular zones were studied because they could be used as alternative data for updating the physical plan of the university. The methodology for analysis spatial modeling of these zones was based on the theory of a weighted additive approach for classification of land capability. The level of land capability depended on a diagnostic factor which could influence the capability of land in different ways. The formula for this method is;

$$S_{r,c} = W_i \times A_{1k} + W_2 \times A_{2k} + W_3 \times A_{3k} + ... + W_n \times A_{nk} \qquad (1)$$

$$S_{r,c} = \sum_{I=1}^{n} W_i \times A_{ik}$$

where

$S_{r,c}$ is the potential of land capability in grid cell row =r and column =c

W_i is the weight of factor I

A_{ik} is the score or of attribute 1 until n of factor k

So, from this equation, the influences of all factors were integrated together and the importance of the factors depended on their weight. The steps of this methodology are as follow;

1) Determining of diagnostic factor's score.

The selected layer as diagnostic factor and its scores are described below;

- Landuse 1997.

The highest score for this factor is a 4 for land use type, bare land which is available for new construction. The next score is a 2, for agricultural field because the it is just a small proportion of this landuse type that has been used. The lowest score is a vegetation area because it should be reserved.

- Physical plan.

For the land capability for academic zone, the highest score for this factor is a 4, for academic reserved areas for keeping the academic buildings together. The next score is a 2, for reserved areas for development. In the same way, land capability for administrative zones and residential zones should be in the areas of administrative and residential zones in the physical plan were scored is a 4.

- Distance from academic, administrative and residential buildings.

Each group of buildings were buffered by a distance of 50,100,200 and 400 m. The Highest score was in the closest distance for the convenience of students and staff in traveling between buildings. The land suitability for academic buildings should be in the closest distance from the group of academic buildings while land suitability for residential buildings should be in the group of residential buildings as well.

- Distance from infrastructure; electricity lines, main water supply pipelines and sewage water pipelines.

Infrastructure has an impact on the capability of the land. The more suitable land for management is that land nearest to infrastructures. The electricity lines, main water pipelines and sewage water pipelines were buffered in the distance of 50 m to 400 m. The highest score for these three layers is a 4, for the nearest area, in a distance of 50 m.

However, factors such as elevation have an influence on the study of land capability but they were not selected because this study area is quite small and these factors do not vary significantly throughout the study area.

2) Determining weight for diagnostic factors.

After the selected layer and its attributes have been given a score, weighing of each factor layer was considered depending on their influence to the land. This study gave the most importance to the land use and physical plan layer because the first thing to consider for new buildings is that the land should be empty and it should be in the specified zone according to the physical plan. The weight for the land use layer is 50 while the physical plan layer is 40. Other factors, distance from building and infrastructure, were considerable less important than those factors above. The weights for distance from buildings, distance from electricity, and distance from main water pipelines and distance from sewage water pipelines were 7, 1, 1 and 1 respectively.

3) Calculation of land capability.

Each factor layer was calculated by using their score plus weight. Then, overlay operations were applied for all diagnostic factors and the total score was calculated from the sum of every factor layer. The suitability of land was classed into 4 ranges, vary from the highest suitable to unsuitable form the total score which the higher score is more suitable. The example of weight of selected factor and the correspondent scores for academic zone are shown in table 2.

Table 2. The example of selected factors in land capability study for academic zone.

layer	weighting	Suitable range	score	attribute code	total score (weighting*score)
landuse	50	Highest suitable	4	9	200
		Highly suitable	3	12	150
		moderately Suitable	2	6	100
		Not suitable/Occupied	1	3,10,2,4,5,7	50
zone in physical plan	40	Highest suitable	4	6 or 1	160
		Highly suitable	3	9 or 11	120
		Moderately Suitable	2	10	80
		Not suitable/Occupied	1	2,3,4,5,7,8,12,13	40
distance from study building	4	Highest suitable	4	1	16
		Highly suitable	3	2	12
		Moderately Suitable	2	3	8
		Not suitable/Occupied	1	4/5	4
distance from road	2	Highest suitable	4	1	8
		Highly suitable	3	2	6
		Moderately Suitable	2	3	4
		Not suitable/Occupied	1	4 or 5	2
Distance from electricity line	1	Highest suitable	4	1	8
		Highly suitable	3	2	6

		moderately Suitable	2	3	4
		Not suitable/Occupied	1	4 or 5	2

Remark 1) Land use type 3= Study buildings, 10= Service building, 2=Residential building, 6=Vegetation, 12=Agricultural field, 4=Recreation, 5=Water body, 9=Bare land, 7=Roads
2) Physical plan 1=Academic zone, 2=Administrative zone, 3=Service zone, 4=Recreation, 5=Residential area for staff, 6=academic reserved area, 7=dormitory zone, 8=Cultural center, 9=Reserve area for development, 10=Reserve area for natural resources 11=Agricultural field, 12 water boy, 13=buildings
3) Distance from study building, 4) Distance from roads and 5) Distance from Electricity line
1= < 50m, 2=50m-100m, 3=100m-200m, 4=200m-400m, 5= >400m

5. RESULT AND DISCUSSION

5.1 The establishment of an Infrastructure database.

1) land use map in 2004

In 2004, land use was classified into 14 classes and the area of each land use types was calculated. It has been shown that the biggest proportion of the land is in land use type of agricultural field about 32.36%, vegetation about 23.73% and bare land about 23.71% respectively.

The attribute data included academic, administrative and residential building database which the detail were as follow;

- academic database included the details of the buildings such as the area for study, service of each building.
- Residential database included the details of the buildings like name of building, type of building, Residential name, number of people and affiliation.

2) Physical plan in 1979

In 1979, there were 11 zones for Land use activities in the campus; academic zone, administrative zone, recreation zone, residential zone for staff, reserved area for academic expansion, dormitory zone, cultural center, reserved area for development, reserved area for natural resources and agricultural field crop. The biggest proportion was agricultural fields and residential zones for staff, about 41.25% and 23.58% respectively.

The figure of land use in 2004 and Physical plan is shown in figure 2.

3) Infrastructures

There are 4 layers of the infrastructure database that have been established as follow;

- **Electricity lines.**

KKU has had its own power plant since 1999 and the electricity cable was transformed from Aluminum into aerial cable with power of about 22KV from a 115/22 KV power plant. There are 4 types of electric lines called feeders which are located in different parts of the campus. Feeder 4, located in the academic zone in the middle part of the campus, has the longest cable with the length of about 9.6 km. The location of transformer point was created with its attribute data described its detail in location and equipments.

- **Water pipeline.**

There are 3 layers for water pipelines including main water pipelines, sewage water pipelines and raw water pipelines. The main water pipeline has several sizes of the pipelines raging from 40 mm to 250 mm. the size of 100 mm and 125 mm, the highest length, were used in the academic zone. Sewage water is discharged to waste water reservoirs which are located in the northeastern, northwestern and in the middle part of the campus. The elevation in the campus is ranging from low to high elevation form the southern to northern part so there is no waste water reservoir in the southern part. Raw water was pumped from the reservoir outside the campus by a pipeline 150 mm in size and used pipelines from 100 mm to 250 mm in size to distribute water for use on the campus.

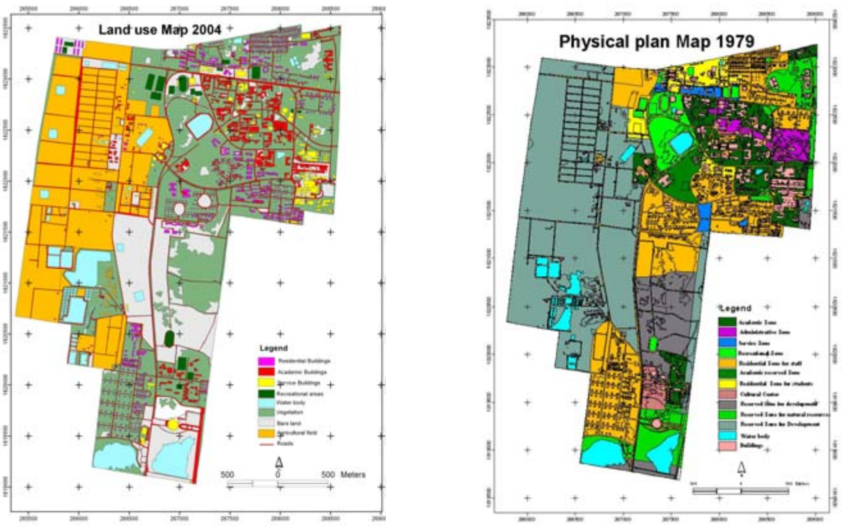

Fig. 2 . Land use Map in 2004 and Physical plan Map in 1979

- **Fiber optic cable.**

Fiber optic cable phase I and Phase II were established in 1998 by using Asynchronous Transfer Mode (ATM) technology. The ATM equipments are stored in several buildings in academic, administrative and residential zones and the details of the ATM equipment were linked to the buildings as an attribute database.

For instance, Fiber optic cable has divided into 2 types; Fiber optic 12 core multi mode and Single mode. The first connected buildings in the academic zone while the second one connected the academic zone in the middle part of the campus to the demonstration school in the southern part.

- **Elevation**

The highest area of the campus is in the agricultural crop field in the north at about 205 m while the lowest part is at 157 m in the south of the campus. Figure of infrastructures map are shown in fig 2.

5.2 land use change pattern in the campus.

1) Land use in 1967,1976,1992 and 1997

Aerial photos taken in 1967,1976,1992,1997 and the Quick Bird Satellite imagery taken in 2004 were used to study spatial distribution patterns and land use change in relation to the physical plan set up in 1979. The results from this study are as follows;

From 1967 to 1997, the numbers of faculties have increased from 3 to 16 which effect land use changes in the campus area. The academic buildings were located in the central part and expand into the northwest and southeast of the campus area while service buildings like library, cafeteria and hospital were in the next ring. The dormitories for students, flats and houses for staff were in the next ring and recreational areas were on the outskirt. This spatial distribution pattern is according to the physical plan.

Land use in each year has changed as a result of building expansion. The biggest area in 1967, 1976, 1992 and 1997 was in grass land which occupied 52.69% while in 1976, 1992 and 1997 was in Agricultural field which occupied 33.74%, 32.72% and 32.36% respectively. It should be noted that in 1967 most of the area was unoccupied so most of it was grass land and brush but several years later it was changed to agricultural fields for the faculty of Agriculture. The figures of land use in 1967, 1976, 1992 and 1997 are shown in figure 3 and the area comparison between each land use type are shown in figure 4.

2) Land use change from 1967 to 1997.

Between the times of 1967 to 1997, the University had developed rapidly. Land use had mainly changed from bare land into buildings. The area of vegetation had interesting increasingly from 1967 to 1992 because they were reserved according the physical plan in 1979. However, from 1992 to 1997, land use types that had increased were bare land, academic buildings and roads. As a result, the vegetation area have declined as a result of increased building. A less active area was in the western part of the campus which has been used just for agricultural fields and they occupied the big proportion of the land. the percentage of changed area from 1967 to 1976, 1976 to 1992 and 1992 to 1997 are show in table 3.

Table 3. The Percentage of changed area during 3 periods from 1967 to 1976, 1976 to 1992 and 1992 to 1997.

Landuse Type	Percentage of changed area		
	1967 to 1976	1976 to 1992	1992 to 1997
Study building	0.63	0.98	0.22
Residential buiding	0.33	1.71	0.51
Rescreation	0.05	0.56	0.03
Water body	0.57	1.62	- 0.06
Vegetation	- 7.03	15.16	- 5.03
Roads	1.57	1.68	0.40
Swamp	- 1.54	0	0
Bare land	0.35	9.41	2.88
Service building	0.06	0.47	0.25
Agricultural field	33.74	- 1.02	- 0.36
Grass land	0.32	- 6.26	0
Bush and shrub	- 28.50	- 24.19	0
secondary roads	0.02	- 0.46	1.04

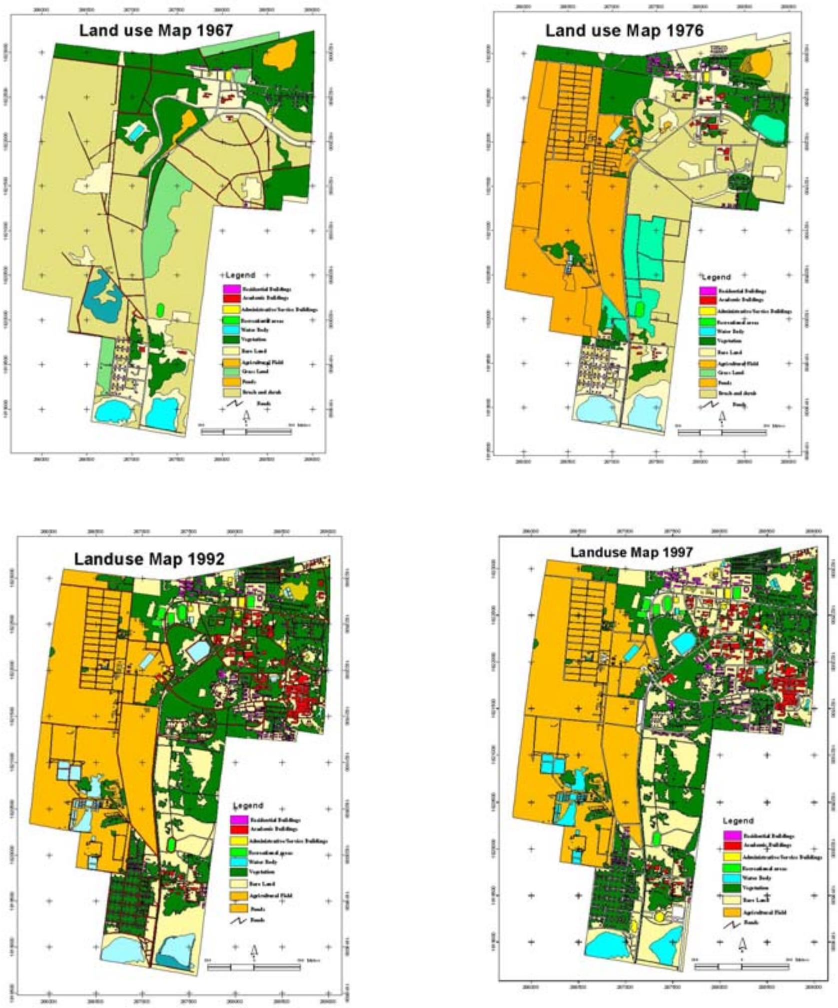

Fig. 3. Land use in 1967, 1976, 1992 and 1997

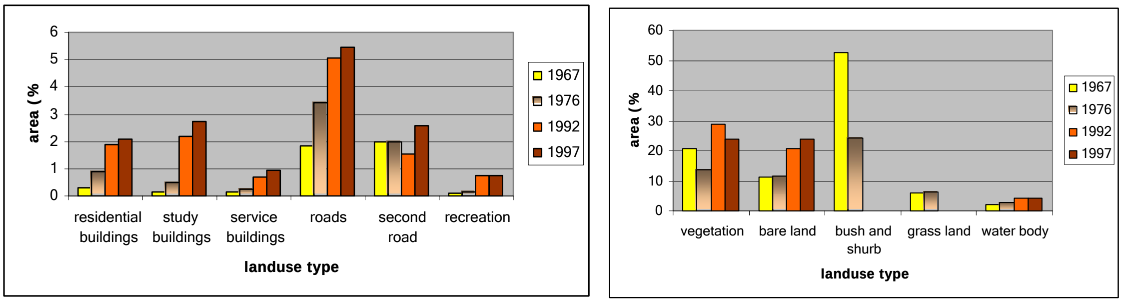

Fig. 4. The percentage of area in each land use type.

3) The change detection between land use in 1992 and 1997 with the physical plan.

An analysis of land use change after the physical plan was set up was done by overlay land use maps in 1992 and 1997 with the physical plan map. In 1992, land use that was not according to zoning by the physical plan were listed. For example, in the academic zone, there were service buildings, agricultural fields and residential buildings, about 1.02%, 3.75% and 0.76 % respectively. While, in 1997, there were service buildings, agricultural fields and residential buildings, about 1.58%, 3.75% and 0.76% respectively. The reason why land use was not according to the plan was because the developments in some areas were not referred in the plan and because the physical plan was out of date and it has not been adjust to be effectively used. Missed used land

5.3 A spatial modeling of academic, administrative and residential zones.

As a result from the study, the Percentage of area for the highest suitable, high suitable, moderate suitable and unsuitable of each were shown in table 4.

Table 4. The Percentage of area in each suitability class of each zone.

Suitability Class	Area (%)		
	Academic Zone	Administrative Zone	Residential Zone
Highest Suitable	24,47	3,63	11,53
Highly Suitable	15.13	48.18	56.57
Moderately Suitable	50.99	21.53	16.93
Not Suitable/Occupied	9.41	26.36	14.97
Total area	100.00	100.00	100.00

The Highest suitable areas for academic zone most were found in the distance of academic buildings and bare land. The highly suitable areas were not in the group of academic building but there were still close to infrastructures. In addition, for administrative zone, The highest suitable areas were most found in administrative zone according to the physical plan and bare land while the highly suitable areas were found in the reserved area for development. For the residential zone, The highest suitable areas were in the residential zone according to the physical plan while the highly suitable areas were found in the reserved area for development and in agricultural field. The Land use capability for academic, administrative and residential zone is shown in figure 4.

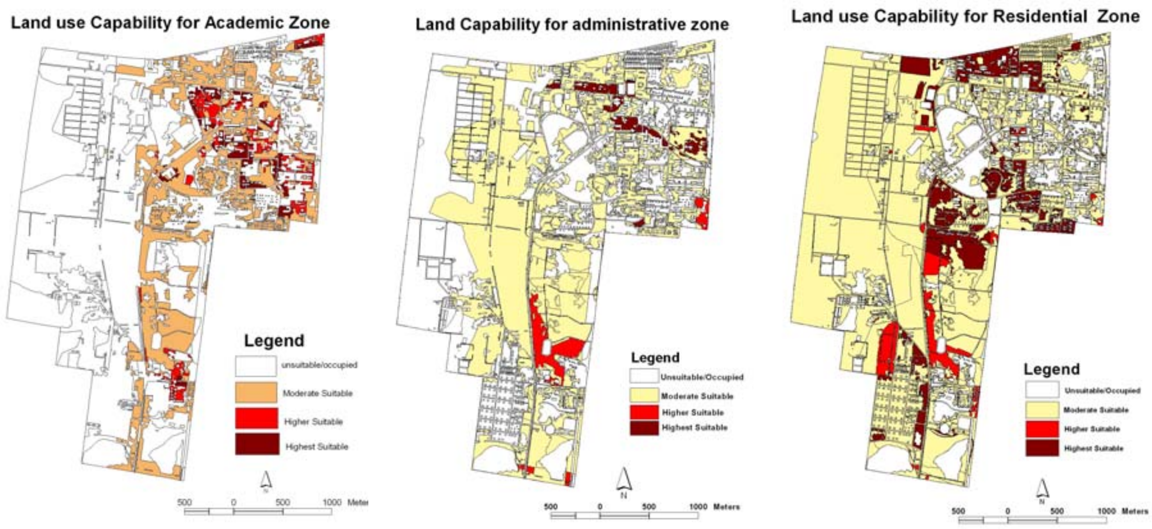

Fig. 4. Land use capability for academic, administrative and residential zone.

6.CONCLUSION AND RECOMMENDATION

The use of a spatial infrastructural database can reduce the redundancy of all concerned data and maintain one central repository of essential data that can be easily updated over time. Land use map in 1967, 1976, 1992 and 1997 can be used to detect changes in land use patterns over time through a university campus. Finally a spatial infrastructural database would be useful in the spatial modeling of academic, administrative and residential zones of a university with helpful supporting data for campus planning in the future.

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