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APPLICATION OF GIS FOR THE DEVELOPMENT OF AN AUTOMATED LAND INFORMATION SYSTEM: A CASE STUDY ON KHULNA DEVELOPMENT AUTHORITY

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Abstract: The study describes a simple technique to formulate an automated land information system using PC based Arc/Info GIS. Thematic information on land use, land ownership, plot height, slope, infrastructure facilities, building structure and building construction setback rules are integrated together using GIS to monitor and regulate physical development of city using KDA as case study. The study also demonstrates the capability of GIS technique to identify the planned and unplanned development activities and delineates the probable waterlogging areas which would help the decision makers to take appropriate measures for development of the city at the right time.

Keywords: GIS; LIS; KDA; Land use; Planning; Development control

Introduction

"Land" denotes physical objects and social institutions, a bundle of earth materials and vegetation cover and a bundle of legal rights to their use (Sinha, 1998). It has often been identified as the most important resource in Bangladesh. Most of the social conflicts in both urban and rural areas occur with the land-related activities and its improper management. However, the planners and decision makers in Bangladesh have to perform their land related works without adequate access to information and research facilities necessary to support the planning and management of the land and related resources (Hossain, 92). The effects of this are more apparent in fast growing urban centers which are characterized by poor housing environment, traffic mismanagement, unbalanced and insufficient distribution of utilities and services and generally incompatible and haphazard urban development.

The Committee on Land Records and Survey Evaluation has pointed out the various problems and their grave consequences owing to absence of an organized land information system (MOL, 1989). The MOL report has examined the various aspects relating to information management and parcel-level record keeping concerning land subdivision, aggregation, transfer of ownership, taxation, change in use etc. At present, these pieces of information are collected and stored in traditional handwritten documents, making subsequent retrieval very difficult. Any query into the urban land of such information base, therefore, takes weeks or months rather than minutes or hours. As a result most planning and management exercises avoid proper analysis of relevant data.

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A computer based system can facilitate the creation of a Land Information System (LIS) that allows easy storage, updating, retrieval, and mapping of a wide range of information related to planning and management of land resources (Hossain, 1992). A LIS is a special type of Geographic Information System (GIS) that includes land ownership, municipal data layers as street network, location and attribute records for the land parcels and lots, flood plain hazard, a base map, and utility networks (Aronoff, 1993). The inventory, analysis and mapping capabilities of GIS have wide applications in urban and regional planning, ranging from data retrieval and site selection to project monitoring and programming (Marble and Amundson, 1988, Levine and Landis, 1989). It is used in information retrieval, development control, mapping (Newton and Crawford 1988; Zwart and Williamson, 1988) site selection (Hoque, *et al*., 1997), land suitability analysis (Lyle and Stutz, 1987; McDonald and Brown, 1984), and programming and monitoring (Yeh, 1990).

LIS is very important especially for the urban areas and in areas where environmental management is a crucial issue (Quium *et al*., 1992). In rapidly growing cities like Dhaka, Chittagong, Rajshahi and Khulna, management of urban land, exercising land use control for the urban planning, planning of utility services and pursuing land and housing policy can be done by using GIS for developing an automated land information system. GIS is now proved to be a powerful analytical tool for geo-spatial decision making (Aronoff, 1993; Burrough, 1993) and the most viable option to resolve existing haphazard development activities, improving their planning methodologies and providing alternative approaches to cope with future requirements. In this study, an attempt is made to develop a simple technique for development of automated land information system for Khulna Development Authority (KDA) through the application of Geographic Information System.

Objectives of the Study

The study intends to assess the application of GIS as a methodology for development of an automated land information system for structured data management, improving planning process, retrieving and updating the file management system. The specific objectives are:

- Formulation of spatial and attribute land information data base of the study area;
- To analyse the data according to rules and regulations exercised by KDA; and
- To identify the land uses affected by waterlogging.

Materials and Methods

A number of thematic maps and other related published maps and reports have been used for the study (Table 1). The maps available from KCC and KDA are not in the same scale, so the maps were standardized to a fixed scale. Digitization of all the spatial data are performed at a scale of 1”= 66ft. with PC Arc/Info software in association with Suma Grid Micro Graphics digitizer. The digitized data was transformed in the global context by using Bangladesh Transverse Macerator coordinate system (BTM).

Study Area: Khulna Development Authority (KDA) is the only organization for development in Khulna urban area. It was established in 1961 under the Ministry of Works with a view to developing the city. It lies between latitudes $22^0 46'$N and 22^0 $54'$N and longitudes 88^0 $30'$E and 89^0 $32'$E. The main objective of KDA is to monitor and control the unauthorized development and to expedite the planned growth of the city. The development control of KDA includes development permission, identification of illegal development and enforcement of law and regulation related to the development control. In addition to this, KDA provides housing plots, industrial plots, civic facilities and other zoning plan for the development of the city. A partial area of ward no. 32 in the City Corporation is selected as a case study for the purpose of this paper (Fig. 1).

Fig. 1-2, 4-5.

Table 1. List of thematic maps for spatial analysis in PC Arc/Info.

Major features	FeaturesClass	Thematic map	Scale	Sources
Land elevation	Line	Contour line on the *mouza* map	1″= 66 ft	KDA
Land ownership	Polygon	Existing land ownership in the *mouza* map	1″= 165 ft	KDA and Field survey '97
Road netwok	Line	Existing road network in the *mouza* map	1″= 330 ft	KCC and Field survey '97
Land use	Polygon	Existing land uses in the *mouza* map	1″= 165 ft	Field survey'97
Building structure	Polygon	Existing building/ structure in the plot	1″= 66 ft	Field survey'97
Drainage line	Line	Existing drainage network in the *mouza* map	1″=330 ft	KCC and Field survey '97

A plot to plot field survey has been conducted to collect land use type, land ownership, and height of the plot, setback of the building structure and building height. Road and drainage network has also been included in this survey. All the information of the field survey is plotted in the existing *mouza* map. A total of 136 plots was surveyed to collect details of their information. Data on planned and approved buildings/structures have been collected from the KDA. Unplanned and unauthorised buildings/structures have been identified during field survey. Length, width and floor space of the buildings/structures were measured during field survey and plotted in the *mouza* map. Table 2 presents the sources and types of attribute data for development of LIS for KDA.

Table 2. Sources and types attribute data for development LIS of KDA.

Attribute Data	Spatial data	Purpose of integrating of attribute and spatial data
Land use pattern	Land uses on the *mouza* map	to display the distribution of land uses of the study area for monitoring and regulating the development of KDA
Ownership data	Land ownership on the *mouza* map	to show the actual number of houses and counted population and density that help calculate future demand of the city.
Individual plot height	Land elevation /contour on the *mouza* map	to identify the land elevation and slope of the land that help delineate the land use zoning and take sustainable measure in the flood affected area.
Information about structure	Building structure on the *mouza* map	to show the authorized and unauthorized building according to height
Building use and KDA setback rules	Building structure on the *mouza* map	to display the unauthorized buildings/ structures that indicate unauthorized structures help the decision makers to take appropriate measures for exercising building construction rules and regulations.
Drainage length and width	Drainage line on the *mouza* map	to show the drainage network that helps determine the catchment area and delimit flood risk zones.
Road length and width	Road network on the *mouza* map	to display the road network.

Database Management: The data management component of the study includes encoding the data and automated into the computer to store and retrieve data from the database. Two types of data (Spatial and Non-spatial) were entered into the computer for the development of LIS in the study area. The spatial data collected from plot to plot survey were automated through the process of digitization and the non-spatial data associated with the spatial entity were entered from the keyboard into the spatial structured table in a relational database. A typical entity relationship diagram for the development of LIS is shown in the following Fig. 2.

Results and Discussion

In the LIS data base for the individual plot of parcel is stored against a unique identification number (ID number) as a form of spatial data (Fig. 3). The land use categories of the individual plot is stored in a database (DBF) file with the same identification number as a form of non-spatial data. These two data files (spatial and non-spatial) are joined with the common items to produce a single database that helps to prepare the land use map. All the analyses were conducted of the collected data stored in the automated LIS data base through the analytical support of ARCEDIT, ARCPLOT

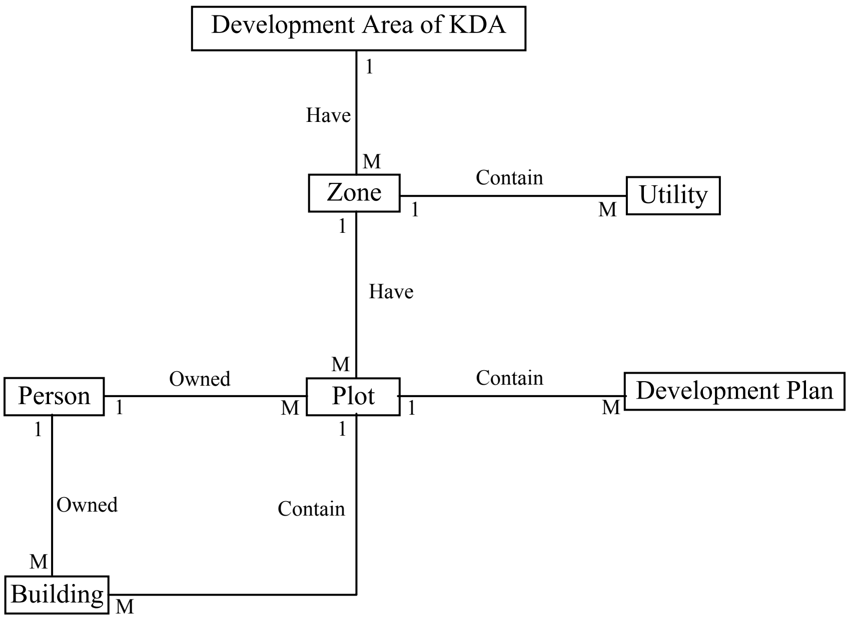

Fig. 2. Entity relation diagram.

and OVERLAY module of PC Arc/Info 3.4D Software, under GIS technology. The resulted maps are discussed in the following paragraphs. There were ten categories of land use identified in the study area (Fig. 4). The residential use covers the maximum land (40.9%) followed by commercial uses such as banks, residential hotel, government and non-government office buildings, etc. (Fig. 5).

Building Structures

Every building structure was identified during field survey and labeled as unique identifier for the development of LIS (Fig. 6). All the structures are categorized into six uses and integrated with the building structure DBF file according to planned and unplanned structure (Fig. 7). Table 3 shows

Fig. 6-9.

the total number of authorized and unauthorized buildings/structures in the study area. It is revealed that only 16.21% structures were planned and approved by the authorized officer of KDA and the rest (83.70%) did not abide by maintain building construction rules and regulations.

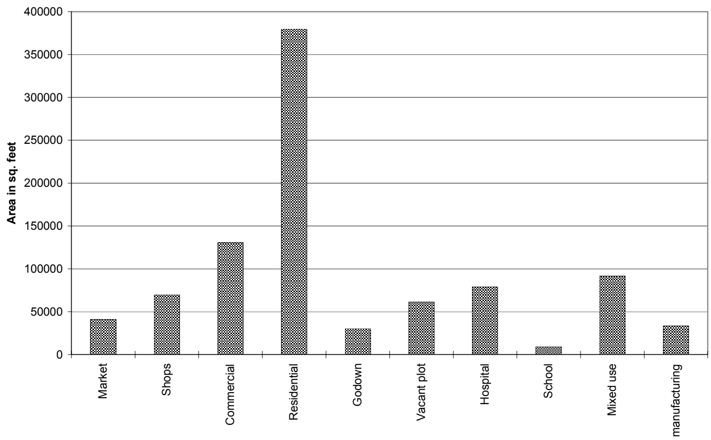

Figure 04 : Land use of the study area

Table 3. Authorized and unauthorized buildings/structures according to use.

Building type	No. of building	Number of building	
		Authorized	Unauthorized
Residential	192	30	162
Office building	42	9	33
Market	3	2	1
Shops	28	7	21
Manufacturing	19	0	19
Mixed use	12	0	12
Total	296	48 (16.21%)	248 (83.70%)

Source: Field Survey, July 199.

Most of the buildings in the study area were found to be one storied each (58.12%), followed by two storied (20.94%) of the total building number (Table 4). Figure 8 shows the stories of the building structure in the study area. Through this map the skyline of the study area can be easily identified and can also make decision-makers to control or to provide alternative approaches to future measure to be undertaken.

Table 4. Number of buildings according to height.

Building storied/height	No. of building	% of the total
One storied	172	58.11
Two storied	62	20.94
Three storied	48	16.22
Four storied	12	4.05
More than four or high rise	2	0.68
Total	296	100.00

Source: Field Survey, July 1997.

Fig. 10-13.

Setback Rule

According to the Section 18 in the Building Construction Act, 1952, the development authority of the government imposes some rules and regulations for the maintenance of the vacant space to be kept on each side of the building. These rules insist the owner of the house to ensure proper gap between the buildings for passing through adequate light and air. According to the setback rules in the Act, the plot size is shown in Table 5.

Table 5. The vacant area on each side of the structure according to the setback rule.

Land use	Plot size (Sq. meter)	Minimum open space around the structure in meter		
		Front side	Back side	Each side
Residential	Upto 134	1.5	1	0.8
	134-200	1.5	1	1
	200-268	1.5	1.5	1
	More than 286	1.5	2	1.25
Commercial	-	1.5 from site edge or 4.5 from center of the road, which one is the higher	1.5	1.5

Source: Bangladesh Gazette, July 1996.

Thus every landowner should maintain and follow the setback rule approved by the concerned authority. But in practice it was found that 242 structures out of 296 were unplanned (Table 6).

Table 6. Number of building constructed according to setback rule.

No. of structures	Planned structures		Unplanned structures	
	Follow rules	Not follow rules	Follow rules	Not follow rules
296	10	38	6	242

Source: Field Survey, July 1997.

The drainage network and contour height of the plot were used to delineate the water logging zone in the study area. In this case the area below the average contour height 10.90 feet is considered water logged area (Fig. 9).

The width of the drainage network having 4.00 feet and 2.50 feet were identified. It is assumed that the catchment area of the drain of 4.00 feet is 100 feet and the drain of 2.50 feet is 50 feet respectively. Thus a buffer zone of 100 feet and 50 feet around the drainage network was created (Fig. 10). The contour map of the study area and the buffer distance around the drainage were integrated to identify the land elevation outside the buffer zone. The maximum and the minimum contour height of the study area are 13.10 feet and 8.30 feet respectively. Thus, the land below the average contour height of 10.19 feet and the area outside buffer zone are considered the probable water logging area in the study area (Fig. 11). The total water logged area is found to be 107714.44 sq. Feet, comprising 11.60% of the total study area affecting 2.55% of the total structures. The affected land uses and building structure are shown in the Figure 12 and Figure 13 respectively.

Conclusion

The GIS provides invaluable assistance to the city development authority to maintain planned and controlled development. The Brundtland Report " Our Common Future", prepared by the World Commission on Environment and Development for the General Assembly of the United Nations in 1987, outlines a number of approaches, many of which would be greatly assisted by the application of GIS. The report calls for a sustainable development strategy, which ensures human progress for today without bankrupting the resources for the future generation (Brundtland, 1987).

The installation of GIS is not a necessary prerequisite for the development of an automated land information system and good planning approaches. GIS can give an opportunity to planners, developers and decision makers to improve their planning methodologies and management systems emphasized on quickly and selectively retrieval of land information data and to draw conclusion and to make decisions on certain aspect of city development. The present study highlights some benefits of using GIS in the development control process with the example drawn through an automated land information of KDA. The results obtained from the study were verified in the field and found reasonably satisfactory. However, as the accuracy of the results of these kinds of studies directly dependent on the quality of input data and updated regular basis, an accurate thematic information is mostly desired.

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