Urban planning advanced analytic techniques and the human role: a challenge or a complement

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The leap that was taken by analytic tools used in urban planning and urban design has formed a tremendous difference between the past and the present times in their capabilities, efficiencies, and possibilities. Rather than the manual manipulation of spatial and non-spatial data, advanced tools with their digital approach in handling various types of data make a great difference in precision, time saving, and costs saving as well. The research carries a comparative study between the performance of human roles and that would be expected by the utilization of these advanced tools in geographic analysis like remote sensing technology, geographic information systems, usage of geographical positioning systems, and the advanced links between computer aided design systems and building the geographic base of a certain area. As a clarifying tool, these advanced techniques give advantage to applications of urban studies like urban planning, urban design, environmental planning, regional and rural planning. Still the human role is essential in composing the appropriate criteria of data input from various sources, surveying areas under study and deducing valuable information that would be digitally translated for the utilized system. Also, deduction of the importance of the final output from urban analysis is done through the human role.

إن القفزة التى حدثت بالأدوات التحليلية للتخطيط العمرانى و التصميم الحضرى قد شكلت فارقاً واسعاً بين الماضى و الحاضر فى إمكانياتها و كفاءتها و أدائها. فبعكس المعالجة اليدوية التقليدية للبيانـات الفراغية و غير الفراغية، تمثل الأداوات المتقدمة بمفهومها الرقمى فى إستخدامها فى معالجة الأنواع المختلفة من البيانات فارقاً كبيراً بالنسبة للدقة، إختصار الوقت، و أيضا إختصار النفقات و التكلفة. يجرى هذا البحث دراسة مقارنة بين قدرات الأداء بإستخدام الأدوات التقليدية و بين ما هو متوقع بالفعل من إستخدام تلك الأدوات المتقدمة للتحليلات الجغرافية مثل تقنيات الإستشعار عن بعد، نظم المعلومات الجغرافية، إسـتخدام نظم التوجيه الجغرافى، و الصلات المتقدمة بين نظم التصميم بمؤازرة الحاسب و بناء القاعدة الجغرافية لمنطقة معينة. و كوسيلة توضيحية، تكسب هذه التقنيات المتقدمة ميزة لتطبيقات الدراسات العمرانية مثل التخطيط العمرانى، التصميم الحضرى، التخطيط البيئى، و التخطيط الإقليمى و الريفى. و مازال الدور البشرى يمثل ضرورة لتكوين المنهجية و الوسيلة المثلى لإدخال البيانات من مصادرها المتعددة، القيام بالمسح الميدانى للمناطق تحت الدراسة، و إستنتاج المعلومات القيمة و التى يمكن تحويلها رقمياً للنظام المستخدم. كذلك فإن إستنتاج أهمية الخرج النهائى الناتج من التحليل العمرانى هو نتاج خالص للدور البشرى.

Keywords: Urban planning, Urban design, Regional planning, Information systems, Physical planning analytic tools

1. Introduction

Deep differences between the traditional methodologies of physical planning and design, and the advanced recently emerged and currently used techniques are emphasizing the necessity to utilize these techniques rather than the old traditional ones. Saving time and costs is the bottom line in their advantages. Minimizing efforts and complications are the direct benefits resulting from using these advanced techniques.

Different tools like digital information systems, computer aided design systems, and remotely sensed satellite imagery, would form a sophisticated multi-tool analytic system that can be used in spatial data manipulation and interpretation of ideas produced by a planner or a designer. Now a day, their costs have been compromised to a degree ensuring their feasibility of usage. Decreasing prices of the systems components encouraged more spread and usage among specialized personnel. This has taken the issue to a degree that more costs (time and effort) would be needed if we go back using the old traditional methods in physical planning and urban design. Still, the human role is needed however, as controlling the data entry by the selectivity of data sources and data quality, and tuning the data

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to an acceptable level, all are still a non-replaceable human role.

Although automation and artificial intelligence technologies have added simplicity and fluency in their usage, the user of these techniques has got many entries to the work team. Selecting and performing the suitable module, and monitoring the quality of the generated information in accordance to its precision and richness are main human tasks, which may orient the analysis to proceed in a certain direction, depending on the application and the case in hand.

2. Physical planning and design as a mind-storming operation

Physical Planning, and urban design are sophisticated processes that require deep thinking and optimization carried by certain expertise (planners and designers) with specialized backgrounds of the concerned sciences. The process is bounded with a set of determinants and constraints, which act as orienting factors deviating the synthetic process towards a certain physical solution. This solution would then be developed as a hard print (a blue print) of a physical planning solution.

2.1.Urban planning

Community planning (with all of its scales) is mainly concerned with finding the best use for land and controlling its development to meet the needs of all groups within a society. Consideration has to be given to housing needs, transport, shopping and leisure facilities, and industrial needs as well as to the protection of the countryside, historic buildings, archaeological features…etc. Planners are aware of the pressures on the environment and are seeking to promote sustainable development to protect the environment for future generations giving the planning process its sustainable character. Urban Planning gets involved in a wide variety of tasks. These can include dealing with applications for planning permission, ranging from house extensions to a new airport, or developing policies for conservation, redevelopment and improvement, or working in a more specialized area of transport planning, …etc. Urban planning studies mind the implications of new development or changes to existing environments and evaluate the impact this will have on the town or countryside and the people who use it [1].

The majority of planners works in local government and advises the elected members on strategy and policies for their area. Other planners are employed by large firms, tourist authorities, environmental organizations or work as private consultants. Planners spend a lot of time dealing with other professions and the public. They have to take advice and opinions from many different people and distil this information so that it assists those who have to take the decisions on planning issues. Planners link knowledge and action in ways that improve public and private development decisions, which affect people, places and the environment. To do this, planners must have knowledge and experience in a wide range of topics. They almost always work as part of a team, either with other planners, other professionals such as engineers or architects, or with politicians and citizens. With the planner's varied background and communication skills, he will often be the one person who brings together a coherent plan of action that draws upon ideas of experts and knowledgeable participants [2].

2.2. Urban design

This practical scientific branch deals with urban spaces inside the urban fabric of a city or a town. Urban spaces are those formed by the urban blocks and constructions. Spaces found among them are called urban spaces that need certain treatment for adding a stylish order, functional facilities for traffic and pedestrian mobility, minding the historic and artistic value of the whole area.

Urban Design would be considered as a macro-scale planning for certain spots. Squares, streets, intersections, piazzas, parks, and playgrounds, all are considered as the working area for an urban design process. Similar to urban planning but with more spatial details, urban design manipulates the urban space for planning its whole overruling guidelines, and designing its details concentrated in its bounding solids, different widths of the mobility stream, outdoor furniture, landscape elements, and the picturesque appearance which the designer aspires to maintain in his proposed solution.

3. Conventional tools and the human role

Limited traditional methods have been used before the emergence of the new technical tools, which will be discussed in the next section. Depending on the human capabilities, produced outputs always have been accompanied with deficiency in accuracy and details, besides they were considered as time and costs consuming operations.

Manual tools, covering the usage of transparent sheets and traditional drafting tools, were used to form preliminary sketches translating the first idea to a readable plot (readable only by its owner) then, and step by step, continuous editing is performed to increase the detailing contents, until the accepted final form is maintained. Till this stage, re-editing and changing in the final plot means repeating the whole plot minding the details whatever the time it consumes. Days and weeks would be the approximate time spans for such operations.

No proper facility would be available for storing and preserving such plots, thus limiting its validity and obscuring any further editing to be performed on them after a long period of time, this is besides their liability to be lost or spoiled.

The previous procedure depended very much on the personal skills of the designer and the drafter in graphic representation. Nonstandard symbols, marks, and drafting technicalities would be utilized differing from a planner or a designer to another, according to his scientific cultural background. This increased the difficulties for dissemination of ideas among the same scientific experts medium because of the difficulty in reading and interpreting the presented plots.

Continuation of the physical planning or design processes by different personnel would be a major difficulty due to the nonstandard variables and indicators used in the designing process, making a necessity for a different planner or designer to revise the whole idea from the beginning to be aware of its details, and then re-plotting its graphic representation once more according to his own view and understanding.

4. Advanced tools and technologies

A set of techniques accompanied with skilled expertise has emerged and rose over the scientific horizons during the last two decades. Tools that are characterized by its computer-power operation capabilities have taken various applications beyond the old traditional methods of treatment and manipulation. Supported with accuracy and high technical capabilities and time saving mode of action, these new techniques gave advantage to various applications that would not have existed without them and without their quantitative and qualitative support.

4.1. Remote sensing techniques

Generally, Remote Sensing is the process of maintaining information about an object or a certain locality by using remote probes and sensors [3]. Also it facilitates acquiring information about certain events through certain censors without direct contact with the event under study. This process takes place from the ultraviolet band to the radio band through the electromagnetic spectrum. Sensors and probes are electronic or optical devices installed on an inhabited or uninhabited space ships, satellites, aerostats, or low-moderate-high altitudes airplanes. Sensed givens are acquired by the sensor and sent to receiving terrestrial stations where they are subjected to computerized processing according to specific systems and programs. From the surveying and geographical points of view, remote sensing works on gathering survey information about the earth surface by outer space photography (satellite imagery) or aerial photography (airborne photographic sensors).

The importance of remote sensing immerges through its different output material like aerial photographs, satellite imagery, and radar photography by facilitating immense quantities of information about the earth and its geographic, topographic and environmental features. It helps in the continuous observation of the earth features and its resources, helps in the preparation of base maps and varying earth features, helps in performing accurate and rapid measurements of distances, areas, and altitudes, and lastly, remote sensing helps in monitoring the dynamic effects and impacts resulting from the human activities in urban areas and natural landscape [4,5].

Multispectral imaging is performed in three spectral bands. The bands used are band "XS_1" covering 0.5 to 0.59 μm (green), band "XS_2" covering 0.61 to 0.68 μm (red) and band "XS_3" covering 0.79 to 0.89 μm (near infrared). By combining the data recorded in these channels, colour composite images can be produced with a pixel size of 20 meters, as shown in fig. 1.

Panchromatic imaging is performed in a single spectral band, corresponding to the visible part of the spectrum without the blue. The band covers 0.51 to 0.73 μm. This single channel imaging mode supplies only black and white images with a pixel size of 10 m, as shown in fig. 2.

Another advanced technique was formulated by the characteristics merging of the previous two types of imageries called “panchromatic plus mutispectral” for studies of small plots for agricultural land covers town planning and urban management gathering high resolution imagery with qualities of multispectral viewing. Data is registered from four spectral bands with 10 m resolution.

As an advanced capability of presently used remote sensing techniques, the three dimensional perspectives (as shown in fig. 3) give a realistic view of the area under study. They can be generated by projecting a satellite image or an aerial photograph over a three dimensional digital terrain (elevation) model (DTM), (DEM) for the area, giving a quite natural scene of the area and facilitating its visual interpretation and analysis [6].

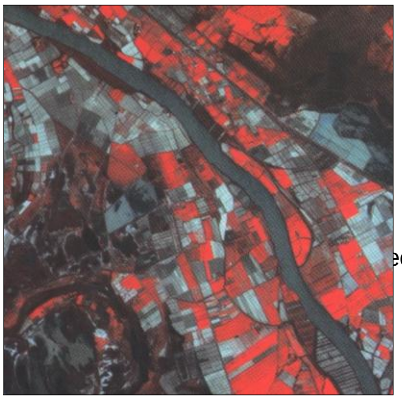

Fig. 1. A multi-spectral image showing the Rhone river path with agricultural land bounding it.

Fig. 2. A panchromatic image showing the eastern margin of Saudi Arabia.

Fig. 3. A digital elevation model (DEM) was superimposed with a SPOT image producing this 3- dimensional image made without any external field survey.

Image processing of satellite imagery is an essential sophisticated step for adapting the acquired images for reading and interpretation. Geometric processing is an important step to eliminate geometrical distortions found in the image and to impose the corrected coordinates of its corners according the used projection system (TM, ETM,..., etc.). Also, the image undergoes a processing step for eliminating the effects of the climatic factors like clouds, gases and water vapor by using special mathematical algorithms [7].

4.2. Computer aided design systems

In general the term Computer Aided Design system (CAD) refers to graphic systems that support the work of architectural or industrial designers. A CAD provides for instance facilities to perform calculations (volume, weight, amount of materials) and produce technical drawings and three-dimensional displays of the design.

A spatial CAD is a tool for urban and landscape design. It consists, on one hand of a database containing spatially referenced (two or three dimensional) data and on the other hand procedures and techniques for data collection, data manipulation (e.g. viewing, zooming, rotation), editing and especially visualization and presentation. Also, automated cartography (mapping) is considered as a part of the CAD systems.

4.3. Information systems

An information system collects, processes, stores, analyzes, and disseminates information for a specific purpose, while a computer-based information system is an information system that uses computer and often telecommunications technology to perform some or all of its intended tasks.

4.3.1. Land use Information Systems (LIS)

A Land use Information System is a tool for legal, administrative and economic management. It consists, on the one hand of a database containing spatially referenced land-related data, and on the other hand procedures and techniques for the systematic collection, updating and query of the data. Very little spatial analysis is performed in these kinds of systems. Applications can be found at Local Governments, Utility organizations and the Water Industry.

4.3.2. Geographic information systems

(GIS) is a young science, which is related to so many other sciences and technologies that deal with spatial data handling. These include remote sensing, regional economics, cartography, surveying, geodesy, photogrammetry, environmental management, geography, and of course, urban, regional, and environmental planning [8,9].

For a GIS, there is wide diversity of definitions. It is a rather rigid classification of the different types of Spatial Information systems that can be encountered.

Fig. 4 shows the GIS as a core tool with various components inputting and outputting from it to complement its analytic role, mainly concerned with the separation of each feature in an individual coverage as illustrated in fig. 5, enabling a precise and rapid analysis for its features.

4.3.2.1. Differences between information systems

The differences between GIS and LIS are not as large on the point of hardware and software. The emphasis in LIS however, lies on storage and retrieval rather than on analysis.

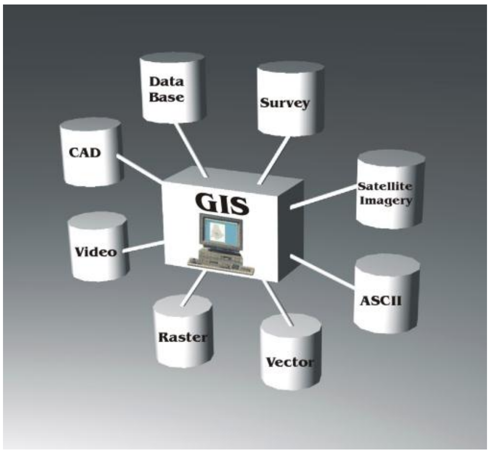

Fig. 4. Different parts involved with the GIS techniques in a one or two-way relation for spatial and non-spatial data manipulation.

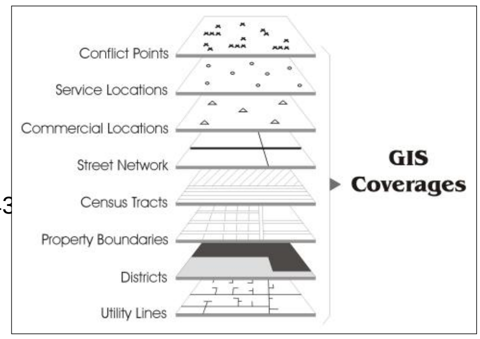

Fig. 5. GIS layering of data in individual coverages, with a unique feature in each coverage, used for spatial and alphanumeric analysis.

The functions needed in a LIS are well short of those in a GIS. Another difference is the scale of the spatial data: LIS usually operates on large scales (roughly 1:500 to 1:1000) data while GIS data are on a smaller scale (1:10000 and smaller), although exceptions are possible.

The differences between GIS/LIS and CAD are much more radical than the differences between GIS and LIS. The orientation in CAD is mainly on visualization, which has led to the development of fundamentally different data structures and approaches [11,12].

The visualization of the design of a building, a town or a landscape has to be perfect for the imagination and marketing of the product. CAD applications are therefore always very impressive to watch. The differences between CAD and GIS/LIS are too large for CAD to find independent applications in spatial planning.

The quality of the future environment also has to be based on both qualitative (design) and quantitative (analysis) information. Therefore an integration of the two systems is important. Thus, the exchange of data from one system to the other is a major step.

4.3.2.2. Virtual reality GIS: The advanced techniques adopted by GIS like "Virtual Reality GIS" uses the natural colors of the LandSat satellite with the topographic digital terrain model (DTM) to produce real three dimensional photographs and dynamic flicks (films) that enables the used of virtual hovering over any part of the area under study. Such revolutionary advancement of GIS gives an untraditional method for visual and digital analysis of geographic locations. Programs used in such applications enable the user of altering his flight altitude and facilitating the usage of these flicks for various purposes like tourism, agriculture, planning, and political studies. Also, this operation facilitates the researchers work, and supports the decision makers with a comprehensive view (most real) for the area under study [10].

4.4. Global positioning systems

The Global Positioning System (GPS) is a constellation of 28 satellites that provide information to GPS receivers, so that software in the receiver can determine a position in three dimensions (altitude, latitude, and longitude). Fig. 6 shows the operation principal of the GPS. From a constellation of 24 satellites (shown in fig. 7) orbiting the earth in 6 orbital planes with 4 in each plane, four satellites (at least) are used to estimate four quantities, longitudes, latitudes, altitudes, and GPS time for each point to be surveyed. By registering each surveyed point on a map, the map dimensions and exact location of its features can be recognized helping maintaining measurements and directions through the previous applications [4].

Originally developed by the U.S. Department of Defense for use in precision weapon delivery, the initial satellites were launched between 1974 and 1977. The use of the system's additional bandwidth was opened for civilian use. This move, combined with recent advances in personal technologies was the catalyst for an explosive surge in GPS market opportunities and intelligent applications. Various applications benefit from the GPS technology like:

- Aviation
- Highways
- Precision timing
- Surveying
- Banking
- Power
- Law enforcement
- Disaster response
- Construction
- Maritime
- Railroads
- Mining/Geology
- Agricultural
- Remote Sensing
- Telecommunications
- Emergency
- Weather
- Recreation
- Environmental management
- Mapping/Geodesy

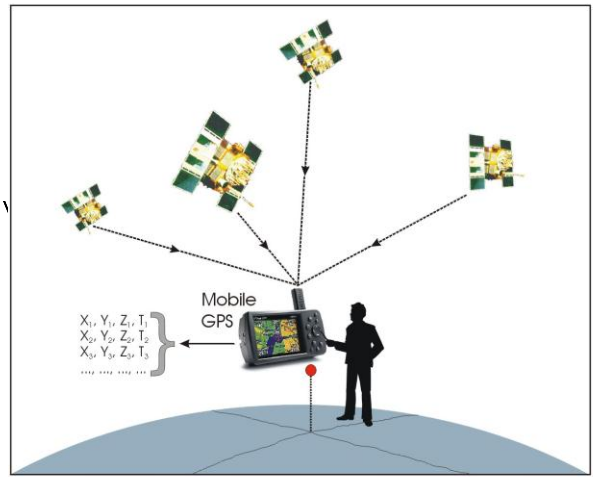

Fig. 6. Measurements of code-phase arrival times from at least four satellites are used to estimate four quantities: position in three dimensions (X,Y,Z,) , and GPS time (T).

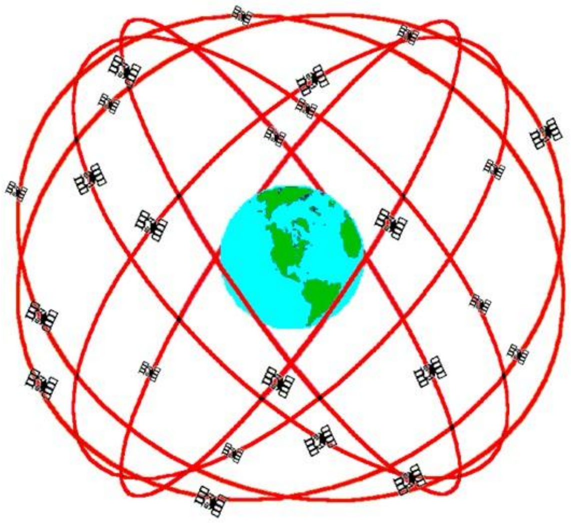

Fig. 7. GPS nominal constellation of 24 satellites in 6 orbital planes (equally spaced 60 degrees apart), 4 in each plane, providing between five and eight satellites visible from any point on the earth.

5. Application precedence of GIS

A geographic information system is a tool for urban and regional research and planning. It consists, on one hand of a database containing spatially referenced geographic related data and on the other hand, in a perfect situation, procedures and techniques for data collection, updating, query, spatial analysis, modelling, evaluation and optimization. On top of this it has elaborated display possibilities.

5.1. Planning

In the sector of regional and physical planning, the use of GIS is much more obvious than in any other application, that's to say, that all relevant information can be easily stored, merged and manipulated.

Land use analysis -which identifies the present or proposed distribution of different land uses including agricultural lands, urban conglomerations, water bodies, desert lands, …, etc - is one of the most important and common branches of planning of a certain area [13].

In other words, zoning identification of different land uses can be plotted on different layers (transparencies or coverages), digitized, then stored in the computer, then different types of processings can be applied like; identification of relationships among different zones, calculated expectations of future boundary changes of different classes or zones, and some other logical operations like estimation of the shortest path of a given segment from one point to another through a multiconditional criteria formed by the analyst.

5.2. Regional planning, environmental planning and protection

Several specific applications are related to risk analysis. Different departments need spatially referenced information that assists their planning and decision making in the event of major environmental disaster. Such a disaster might originate at a point source, such as a chemical explosion at a factory and the emission and spread of a toxic gas cloud (e.g. the Tsjernobyl accident). Or, it might be a linear risk such as the transportation lines for dangerous gas by car or boat, or a linear hazard such as a major flood. Planning requires information about the dispersal of the hazard in space and time, the distribution of the population at risk and the location of resources needed to tackle the problem (e.g. availability of transport and temporary shelter). Concrete systems have for instance been designed for the environmental risk of chemical industries, the evacuation in case of flooding, the simulation and mapping of air pollution, and the management of disasters in the North Sea. A GIS is a perfect environment to gather, combine, analyze and display all this information.

Environmental Impact studies and Ecological balancing methods for land use planning and land consolidation are gaining more importance in the planning process. The ever-increasing competition for space between different activities generates more and more land use conflicts. GIS is a useful tool for making an inventory of present and planned land use and environmental quality and impact [14].

5.3. Infra-structure planning

Application of infrastructure framework of different utilities required by the construction of new conglomerations and community clusters like; water supply network, electricity supply, sanitary network, telephone lines, transportation routs, streets' illumination and other utilities.

GIS technology can be introduced in such an application in a manner to overcome the interference of utility networks with each other, also to avoid the short-sight phenomenon in considering the future expansion and decisions taken due to it.

GIS has got also the great ability in the identification of private property of ownerships, curb lines, streets dimensions, and different parameters and technical features concerned with urban areas.

5.4. Urban planning

Urban planning fields may benefit from using GIS giving some details in certain points of view which concern the planner interest such as transportation framework, the urban fabric of an urban conglomeration, utilities (previously mentioned), besides the most important parameter concerning the site evaluation of a certain location.

For a certain area, all parameters covering the demographic variables, or any other parameters characterizing the urban area, can be represented by identical set of maps stored in a computer.

Population records, population density, socioeconomic parameters (income per capita, job opportunities,…,etc.), natural boundaries of the site, dividing the urban area to its major categories (residence, industry, recreation, services, administration,…,etc.) and many other parameters which can be represented in a spatial format like images, maps and diagrams, or non-spatial format like tables, graphs, statistical forms,…, etc.

GIS can be used to select (for example) disposal sites for radioactive wastes, the question was not whether this is the right solution to the waste problem, but to select the best site giving the best situation of having to dispose of it.

An urban planning proposed plan should be characterized by sustainability, as planning with its general understanding is a way of organizing living activities and is not an incident action. Planning makes an alteration in the way of living. Alterations are continuous and tied to each other and framed by the nature of the problem they treat [15].

5.5. Urban planning analytic processes

Certain operations characterize GIS in its analytic role. Various actions can be performed on data in its spatial and non-spatial formats. Mathematical logic operations, forming buffers around certain geographic features, encoding or thematic mapping, and locating geometrical differences, all are some operations that can be held by a GIS.

5.5.1. Logic operations

They are mathematical operation performed spatially to the geometrical entities, like: unifying zones (where two different graphic entities can be unified and redefined as a unique entity), subtracting zones (where an entity is subtracted from another by the overlapping part), and selection of common features (the part in common in two overlapping entities)

5.5.2. Buffers and restricted zones

A controllable buffer or restricted area can be created around a specific feature for the elimination of entry, activities, or any restricted developmental action. This can be applied to sensitive zones like national reserves and parks, or any other land use with high environmental sensitivity.

5.5.3. Geometrical symbolizing and indicators

Assigning symbols and codes (colors, hatchings, marks,...etc) for the differentiation between different clusters and categories, accompanied with a controllable legend.

5.5.4. Monitoring urban expansions and declinations

Also called a multi-temporal analysis. By performing the subtraction logic operation of a map from a different one, changes can be identified in what is called the difference map. It shows the increase and the decrease in any cluster with respect to other clusters.

6. Relations among different elements

The advanced tools discussed in a previous section, would practically interfere in their functioning mode. Each would play a certain role complementing with another tool to produce a certain result that wouldn't be reached without their mutual cooperation.

A whole system for physical planning and urban design purposes would contain several parts like: usage of satellite imagery with advanced capabilities of the needed image processing to adapt the images to the appropriate settings for manipulation and the extraction of information.

As shown in fig. 8, the GIS application modules which act as the processing stage handle the data from different parties and sources [9]. Parts like digital data bases would act as conjugate parts, as the GIS itself is based on a digital data base-handling module. Direct linkage would be formed between external data base modules and the used GIS, while other sources like digital satellite imagery have to be reformatted and adapted to be compatible with the used GIS so that digital images can be entered as individual data layers.

CAD tools may form a direct linkage with the GIS. The majority of the utilized GISs contain a built-in CAD module for editing and modifying graphic entities of the digitized maps.

Concerning outputs, editable maps can be produced from the final analysis, and by the application of the previously mentioned analytic processes discussed in section 5.5. Also, tabular information can be extracted in the form of statistics, lists, and measured figures. Some of the GIS's outputs are procedures, like conditional searching for certain geographic features, the identification of the shortest path between two points, or the creation of buffers and restricted zones. All are some of the procedures of the GIS analytic capability.

7. Concluded remarks and recommendations

Although presently used GISs have got advanced modules for processing and interaction between other information systems, and other analytic tools, the human role played by the user is still inevitable. Acting as a controller and a selector for actions, comparing of available data, and many other essential procedures, the system user complements and integrates with the automated features of the used analytic system. As previously mentioned in section 3, the old traditional methods used for urban planning and design compared to the available advanced techniques would make the choice in favor of the ease and simplicity of these advanced techniques, but still in command-ment of the user.

Fig. 9 illustrates this concept of integration between the user and the automated system of analysis. In each stage, output, input, interaction with other information systems, and the control through given conditions and constraints, the human role is significant. In other words, the user is still responsible of the precision and the quality of the resulting output through the fine-tuning processes performed by the user in many aspects from the beginning of the analytic process till its final stage.

The user also becomes part of the GIS whenever complicated analysis, such as spatial analysis and modelling, have to be carried out.

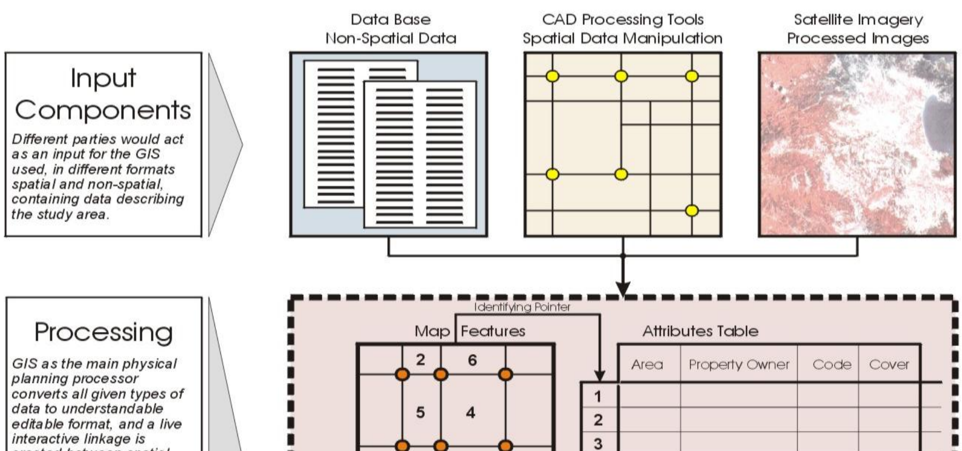

Fig. 8. A diagram showing different components and parties sharing the GIS its analytic role, using various types of data as input and maintaining high quality interpreted multi-formatted information as output.

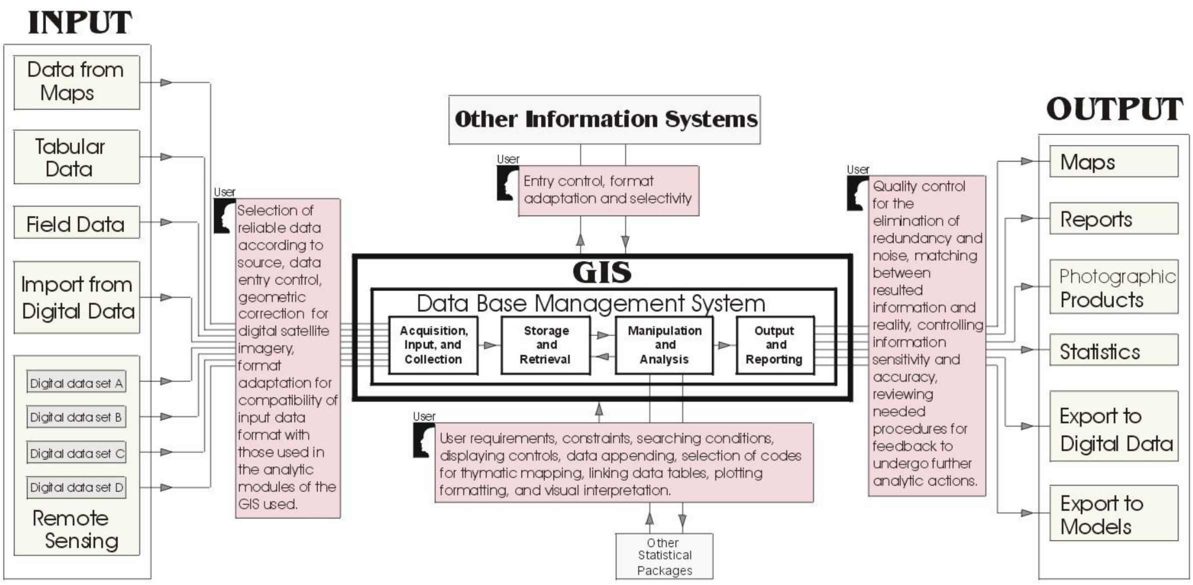

Fig. 9. The human role as a controller and selector in different functional parts of a GIS.

Many organizations now spend large amounts of money on geographic information systems, and on the geographic databases. Predictions suggest billions of dollars will be spent on these items over the next decade. As the costs of computer hardware needed for the GIS and other spatial analytic tools are dropping rapidly, they become affordable to an increasingly wider audience.

On the long run, the use of these systems increase the economic aspects of the planning and the design work, due to the advantages described in section 5, making the use of advanced techniques in these fields more feasible and convenient.

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