HIGH (SPATIAL) RESOLUTION vs. LOW RESOLUTION IMAGES : A PLANNER'S VIEW POINT

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ABSTRACT

The popular belief that the high spatial resolution images will always lead to a better interpretation, may not always be true, from the point of view of an urban and regional planner. A typical urban and regional planner deals with areas to be analysed and planned on maps at a variety of scales, ranging from 1:500 at Site Planning level to 1:250,000 or more at the Regional level. These maps do require different levels of generalization and detailing. While a small polygon at a regional scale could represent a large metropolitan area (or urban agglomeration), a map at an urban (or local) scale would require to differentiate the various land uses and their sub-classification within the agglomeration.

Studies have indicated that when working at a metropolitan regional scale or higher, images with low spatial resolution are actually more useful than images with higher resolution. Low resolution images sieve out unnecessary details, which would be useful only at local level and very disturbing at metropolitan region level. Higher spatial resolution images simply provide too many details for the level of generalization appropriate for decision making at the regional level.

1 INTRODUCTION

Application of satellite images, in almost every field related to Earth Sciences, has come along way. Two important factors responsible for this are the hurdles generally associated with the availability of aerial photographs (specially in many developing countries) and ever improving spatial resolution of satellite images. Application scientists are able to develop newer applications each time a satellite image with a better resolution becomes available. Provision of more details and, therefore, better interpretation are being promised now that these images have become commercially available.

However, the popular belief that the high spatial resolution will always lead to a better interpretation may not always be true, from the point of a view of an urban and regional planner. An attempt has been made in this paper to highlight that while higher spatial resolution satellite images will be very useful for working at urban and local scales, low resolution images will continue to have an upper edge while working at the metropolitan, regional or higher scale. It has been argued that the higher spatial resolution satellite images simply provide too many details for the level of generalization appropriate to decision making at the regional level, rendering these images expensive, time consuming and impractical.

2 THE CANVAS OF AN URBAN AND REGIONAL PLANNER

2.1 Variety of Planning Scales

A typical urban and regional planner deals with areas to be analysed and planned on maps at a variety of scales. While on one hand maps dealing with a regional planning exercise would be plotted at scales ranging from 1:250,000 to 1:1,000,000, those dealing with a planning project/ scheme need to be plotted at scales varying from 1:500 to 1:2,500. The success or failure of a set of planning maps depends to a very large extent upon the suitability of the maps used. The perfect map would be the one that gives just enough detail but no more, to make the information contained on it fully comprehensible. The more detailed the map the less will be the degree of clarity with which the information can be shown. At the same time, too simple a map may also lack in clarity making it useless for the purpose.

2.2 Variety of Planning Information Corresponding to Scales

By practice over the years, and often by statutory requirements, urban and regional planners have come out with following amount of information to be included in maps dealing with various levels of planning (Mahavir, 1986; ITPI, 1996; ITPI, 1998). Even though the list is generalized and actual detail will depend upon the scale chosen, the area covered and principal objective of the planning exercise, it does provide as a broad checklist for the purpose of this paper (see Table 1).

While the listing is indicative of the broad spectrum of the levels of scale and maps that a planner has to deal with, it also indicates that a similarly broad horizon of sources of these data has to be approached for getting the desired information.

3 REMOTE SENSING AS A SOURCE OF PLANNING INFORMATION

3.1 Remote Sensing as a Source of Planning Information

Besides the traditional sources and methods of collection of data for planning, with all their limitations, satellite remote sensing remains the single largest source of collection of data. Aerial remote sensing, though having a lot of promises and proven applications, lags behind due to a policy of restriction (specially in developing countries) and largely being non-digital in nature thus limiting digital processing. Satellite remote sensing, on the other hand, has rapidly taken over the former, due to advances made in data capture technology, spatial and spectral resolutions, data storage and processing equipment and above all, the Information Technology (IT) revolution currently on.

3.2 Popularisation of High Resolution Images

For a long time, images with a low spatial resolution (e.g., 80 m) only could be ordered. A considerable improvement of resolution arrived on the market in 1986 with the 10 m spatial resolution Panchromatic SPOT. These images provided synoptic views on areas as big as 60 km x 60 km where not only a (large) city could be seen but also a large parts of its environment in which it might expand. Constant pressure from the user community and technological innovations made it possible to further improve the spatial resolution to the likes of 5.8 m (IRS – IC and ID) and the more recent 1 m of Ikonos from the Space Imaging Inc. While the scientists providing us the technology are excited over their technological triumphs, the application people are excited in finding new challenges to use these data in order to derive anew and meaningful information about Earth’s surface.

4 IS SMALL ALWAYS BEAUTIFUL ?

The trends of making the spatial resolution finer and the enthusiasm shown by the user community, give to believe the popular saying, ‘Small is Beautiful’. At first impression, it sounds logical too. An urban and regional planner, engaged in city planning in a developing country would be the happiest person to be able to locate precisely the squatter settlements to the extent of individual shelter and lanes and the services, etc. if available. He would also be happy to generate sieve analysis maps to identify potential areas for locating sanitary land filling sites and relocation of squatter settlements, etc. However, as the following discussion will reveal, high resolution images are not so useful at higher levels of scale, (see Table 1) particularly in the filed of urban and regional planning.

Level of Planning Exercise	Range of Scale of Maps	Information Contents on the Base Map and Thematic Maps

Regional Planning	1:50,000 1:100,000 1:250,000 1:1,000,000	Boundaries – National, State, District Sub-District, Village, etc. Roads – International/National Highway, State Highway, Major District Roads, Other District Roads, Fair Weather Roads, Railway Lines – Broad Gauge, Meter Gauge, Narrow Gauge, Single Line/ Double Line, etc. Bridges – Railway, River, Canal, Major at-grade and grade - separators other than city bridges, Water Bodies – Rivers and Streams, Canals, Lakes, Swamps, Marshlands, etc. General Topography – Major Forest Lands, Hilly Areas, Agricultural Areas, Barren Lands, Orchards, Settlements, Contours – 100 m interval, Physical and natural resource potential areas, Natural hazard prone areas, Environmentally and ecologically sensitive areas, Generalised land utilization, Waste and derelict lands.
Perspective Planning	1:50,000 1:100,000 1:250,000	Boundaries – Metropolitan, Urban Area, Municipal Area, Zonal, etc., Roads – National Highways, State Highways, Major District Roads, Arterial Roads, Sub-Arterial Roads, Major Roads, Railway Lines – Broad Gauge, Meter Gauge, Narrow Gauge, Bridges – Railway, River, Canal, At-grade and grade – separators, Water Bodies – River and Streams Canals, Lakes, Swamps, Marshy Lands, Ponds, Embankments, Low lying areas, Religious Places – Temples, Mosques, Churches, Tombs, etc. Places of archeological and historical interests, City forests and parks, Green belts, Cantonment areas, Floodable areas, Sanitary land filling sites, Contour intervals 3-5 m., Land use, Physical infrastructure and networks, Environmentally and ecologically sensitive areas.
Development Planning	1:10,000 1:25,000 1:50,000	All information contents as in Perspective Planning above; Ward wise population and density distribution; Areas served by water mains and sewers (singularly and by both), Large reservoirs, Water supply and sewage disposal works, Gas and electric supply works and lines, Arterial and sub-arterial cycle tracks, Local bus routes, terminals, traffic volumes on main roads, Parking sites and turn overs; Old built-up areas, New built-up areas, Areas with dilapidated buildings, Slums and squatter areas; Areas limiting the development.
Annual Planning	1:5,000 1:10,000 1:25,000	All information contents as in Development Planning above; Land assembly required by the development, components and the manner of land assembly. (However, the focus here is on a 'report' and not on detailed maps).
Projects/ Schemes/ Site Planning	1:500 1:1,000 1:2,500 1:5,000	All accesses; All vegetation (trees, bushes, arboriculture, etc.), Water bodies; High Tension/ Overhead electric and telephone lines, Water supply lines including hydrants, sluice valves, etc; Sewer lines including manholes, vent pipes, etc.; Drainage channels, contours 1m interval, Other physical characteristics of the site.

Table 1. Information Contents at Various Levels and Scales of Planning

4.1 Ease of Interpretation

In a study (Mahavir, 1996) relating to understanding, predicting and recommending settlement patterns for metropolitan regions using remotely sensed data, it was argued that a low spatial resolution of 72.5 m was indeed more appropriate compared to 10 m or 5.8 m spatial resolution available at the time of the study. The study involved the metropolitan region area around Delhi – formally known as the National Capital

Region of Delhi (NCR), India, covering an area of more than 30,000 sq.km. extending over four states (provinces) including the National Capital Territory of Delhi (NCT), India. The Region accommodated a population of more than 26 million people (1991) spread over 100 urban settlements and about 6,700 rural settlements. The study involved mapping of 'Continuously Built-up Areas' of these settlements, applying various projection techniques and models, and mapping 'Continuously Built-up Areas' of the settlements as it would be at a time in future.

The crucial in the entire study was definition and delineation of 'Continuously Built-up Areas'. A number of rules governing minimum curtilage, generalization, idealization, agglomeration, etc. had to be evolved keeping in mind the vastness of the region, an appropriate scale to work upon (1:250,000 in this case), the principal source of data (i.e. the satellite images) and the overall objectives of the study. It also depended upon the area of the smallest expected 'Continuously Built-up Area'. The study finally adopted a minimum curtilage of 4 mm x 4 mm at a scale of 1:250,000 (i.e. 1 sq.km. on ground) and a minimum width of 2 mm (i.e. 500 m on ground). It was concluded under the study (Mahavir, 1996) that the remotely sensed data with spatial resolution of 72.5 m was appropriate for the purpose providing a synoptic view of the entire region under study. It specifically performed the otherwise difficult task of determining the 'built-up' pixel out of a mix of 50 pixels (of 10 m resolution compared to 72.5 m).

One could argue that high spatial resolution image could always be resampled (digitally) with larger pixel size and a relatively low spatial resolution image be generated. Technically the logic is sound, but it would only amount to using a sophisticated tool to make sophisticated data rather simple and then performing the task of analysis on simplified data. In other words, using a high specification computer for performing what a simple calculator might perform. For the paper prints, for visual interpretation, images with low spatial resolution would certainly be handy in delineating 'Continuously Built-up Areas' as explained above. Similarly, host of other information at the regional scale would be easily drawn on a low spatial resolution satellite image. Thus, there is a strong interrelationship among the spatial resolution of the image, the spatial structure of the terrain under investigation and the nature of information sought in any given image processing operation. This must always be kept in mind as one selects the appropriate spatial resolution and analysis techniques for any given setting and application (Lillesand and Kiefer, 1994).

4.2 Data Volume

It was discussed in the above paragraphs that even the high spatial resolution satellite images could be digitally resampled for producing relatively low resolution image for the ease of interpretation. However, one aspect that needs attention is the volume of data one handles in the two cases. As a thumb rule, volume of data to cover the same amount of area on ground with a high spatial resolution image would be far large compared to a low spatial resolution image.

Thus, while an image covering an area of 2,500 sq.km. at a spatial resolution of 72.5 m (IRS-1B) may contain a little over 475k pixels, the same area would require more than 74M pixels at a resolution of 5.8m (IRS-1D. A large volume of pixels, at the same time, will require larger storage spaces, processing time and data acquisition costs.

4.3 Data Acquisition Costs

As in the case of data volume, there can be a thumb rule relating to data acquisition costs and spatial resolution. Broadly speaking, costs of data to cover the same area at low spatial resolution will be much lower compared to covering the same area at high spatial resolution.
For example, a full geocoded scene (148X174 km) of IRS-1A/1B with 72.5 m resolution costs about Rs.4,600, a full geocoded scene (28X28 km) of IRS-IC/ID with 23.5 m resolution costs about Rs.11,500/-. Similarly, a full geocoded scene (14X14 km) of IRS–IC/ID with 5.8 m resolution costs about Rs.28,800/- (All prices in Indian Rupees; Prices quoted by the NRSA, 2000. Prices of non-Indian satellites not compared due to problems of foreign exchange rates and royalties involved). Moreover, the number of scenes required for coverages with high spatial resolutions are more, thus making the data product more costly.

5 CONCLUSIONS

It can thus be concluded that from view point of an urban and regional planner, high resolution satellites images may not always be preferred. While high resolution images may be useful working at scales varying from 1:500 to 1:2,500 (i.e. site planning, projects and schemes), relatively lower spatial resolution images would be more useful for planning at scales varying from 1:25,000 to 1:50,000 or 1:100,000, etc. Though no hard and fast rules can be derived, one has to keep in mind the level of planning, chosen scale for preparing base maps and thematic maps, the level of detailing intended and the objectives of the planning exercise. Keeping in mind the kind of information content on the base maps and thematic maps to be drawn at various levels of planning, following of combinations of spatial resolutions may be recommended (see Table 2).

Level	Scale(s)	Spatial Resolution of Satellite Image
Regional Planning	1:50,000 1:100,000 1:250,000 1:1000,000	72.5 m or lower
Perspective Planning	1:50,000 1:100,000 1:250,000	36.2 m 72.5 m
Development Planning	1:10,000 1:25,000 1:50,000	5.8 m 10 m 36.2 m
Annual Planning	1:5,000 1:10,000 1:25,000	5.8 m 10 m
Projects/Schemes/ Site Planning	1:500 1:1,000 1:2,500 1:5,000	1 m 5.8 m

Table 2. Recommended Spatial Resolution of Satellite Images for Various Levels and Scales of Planning

Higher spatial resolution images may provide better data as thumb rule, it may not always be desired from consideration of the ease of interpretation, data volume and data acquisition costs. While there is a growing tendency to launch more and more remote sensing satellites with finer resolutions and to develop applications for the same, the need for continuation of lower spatial resolution satellites at the same time cannot be undermined.

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