A STUDY ON PRODUCTIVITY OF SATELLITE IMAGES IN THE PLANNING PHASE OF LAND CONSOLIDATION PROJECTS

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ABSTRACT:

Engineers in geomatics are now using high tech technologies which are based on satellite systems. GPS and remote sensing technologies offer great advantages for surveyors. One of the areas where the surveyors are involved is a Land Consolidation project. These projects deal with improving of productivity and working conditions in rural areas, production of reconstruction plans for rural settlement, and proving of rural life by supplying public services. The fulfillment of all those aims more or less depends on supplement of spatial data. During the collection of spatial data, speed and ease crucially improve the productivity of over all these projects. At this point, modern technologies such as remote sensing and GPS can met these requirements.

In this study, satellite images in high accuracy supported by GPS measurements collected on the ground are investigated whether they can be used in the planning part of Land Consolidation Projects, additionally, in update phase of maps, production of topographical maps, land classification part.

1. INTRODUCTION

Significant developments in the field of remote sensing, especially in terms of spatial and spectral resolutions, have widened the application fields of remote sensing and GIS during the last decade. At the same time, advancements in the digital photogrammetric and cartographic techniques facilitate the user a variety of tools for data integration, conversion and manipulation into flexible, efficient and precise spatial databases. Hence, the use of remote sensing high resolution images, especially from IKONOS, Quick bird etc. and to utilize the multi-resolution and multi-spectral data offered by various remotely sensed satellites will be extremely feasible in the land consolidation projects especially in the planning phases. The data provided by various satellites will have met the requirements of decision makers at various scales from regional to micro (village) level. It can also serve a wide range of applications through a centralized database to various government organizations, public undertakings and non-governmental organizations. It is also pertinent here to describe the capability of remote sensing technology visa-vis mapping requirements and availability of maps.

- The (thematic) maps derived using satellite imagery should be appropriate to the spatial resolutions offered by the respective satellites. For example, using IRS-WIFS data thematic maps on 1:1,000,000 scale can be generated. Similarly with LANSAT-7, SPOT-5 Multi Spectral and Panchromatic data, thematic maps on 1:500,000-1:250,000; 1:250,000-100,000; 1:100,000-1:50,000 and 1:50,000-1:25,000 scales at regional, district and local levels can respectively be generated. In the same way, maps with 1:10,000 to 1:2500 scales at city/village can be generated using one meter data like IKONOS, Quick bird etc.,
- The vector data (digitized maps) can be integrated with raster data (satellite imagery) for spatial queries and updating of database/map details.
- With the use of satellite images to provide the spatial database/maps, it will be possible to have a common legend, map layout and information provided on the raster (remote sensing) data and corresponding vector information.
- Map updating as well as thematic map generation up to 1:5000 scales.
- Finer resolution imagery such as IKONOS is very useful in various applications like Urban land use, infrastructure and utility mapping, cadastral survey (at Village level/ survey number wise land utilization), Micro level development, Road/rail/pipeline alignment studies, Land consolidation works, etc.,
- Finer resolution data is very much useful for verification of plan layouts, property tax assessment, Road traffic monitoring, Facility sitting, urban planning and other activities.
- Various urban features including types of residential features (such as individual & row houses, multistoried apartments, slum areas), commercial, industrial, recreational, government organizations, cantonment, and other types of features can easily be delineated.
- Regarding transport network, major roads as well as side lanes (with 5 m wide) can be delineated, also related features such as Flyovers, road dividers, lane markers, signal points, traffic islands etc, can easily delineated using IKONOS.
- Public utilities like electric substations, Gas/petrol Service station, Water supply & sewerage treatment Plants, Telecom centers, Railway and Bus station etc., can be delineated.
- Features with point nature (like wells, fountains, water and Oil storage tanks), Linear features such as fenced boundary wall,

road dividers, pipelines, and erected tall features like electric poles, lampposts, Towers like telecommunication, Radio, T.V., Pylons etc., can be detected with IKONOS data.

On the other way around, the land consolidation works in general and in Turkey include the development of road, water management and drainage, improvement of land and landscape, and consolidation of scattered, fragmented and shared farmplots. The aim is also improvement of agricultural economics and the rights of owners.

The agricultural areas in Turkey have become insufficient due to high population rate and decreasing productivity. The increase of land productivity is related to improvement of land and water resources, technology level, agricultural structure, and the quantity and quality of seed, fertilizer, pesticide and water use. The land consolidation develops agricultural structure, which is one of the main factors in improvement of land and water resources. Fortunately, the opportunities offered by satellite images such as explained above can meet well many of requirements described in land consolidation projects.
The purposes of land consolidation as given in the 3083 numbered and 22.11.1984 dated law, "Agricultural Reform Law for Land Consolidation in Well-Watered Areas" and "Application Regulations" are as follows:

-Connection of highly fragmented plots according to the principles of modern management
-Improvement of land and soil
-Reorganization and improvement of agricultural managements
-Building roads, drainage and water management systems
-Leveling and tree planting of mountainous areas
-Arrangement and reallocation of land and enlargement of managements
-Arrangement of settlements (electrification etc.), joining of scattered plots, improvement of all aspects of agricultural life in order to obtain highest productivity of land and labor, and taking measures in technical, social, cultural and economic aspects to increase agricultural life (Banger, 1992) .

2. BASIC STAGES OF GENERAL LAND CONSOLIDATION PROJECTS

Land consolidation projects generally have four basic stages (Kara, 1980; Takka, 1993; Cay, 2001):

a- Preliminary study
. Preliminary interview with land owners (for demanded consolidations)
. Cadastral procedures
. Determination of project borders
. Preparation of list of old owners and alphabetical list of old owners
(for demanded consolidation)
. Preparation of preliminary study report
. Decision by Ministry Board

b- Planning
. Announcement of land consolidation field and annotation on Land Register
. Determination of present state of project area
. Evaluating ownership state
. Land study and classification
. Formation of blocks (water management, drainage and road systems)
. Determination of stationary establishments
. Determination of share for common establishments
. Preparation of planning report

c- Project making
. Filling out interview forms
. Planning new parcels
. Announcement of new ownership map
. Forming project file

d- Application
. Application of blocks
. Leveling of road and soil, and filling canalet base
. Application and temporary delivery of new parcels
. Land improvement, making stabilized roads, construction of canalets, drainage system and art structures.
. Remeasuring, drawing, preparation and registering new parcels

The Planning Phase in Land Consolidation Projects

In the planning section;
- Determination of present state of project area
- Land study and classification
- Formation of blocks (water management, drainage and road systems)
- Determination of stationary establishments

can be done using satellite images.

2.1 Determination Of Present State Of Project Area

This process includes the determination of stationary establishments such as irrigation canalets, drain structures, road and path networks, water resources, wells, buildings, wire hedge and delineation of them on map So, the cadastral maps can then be updated data.

2.2 Land Study And Classification

Land classification value is computed with respect to soil, productivity and location indexes of plots as shown below,

Plot index (PI) = soil index (SI)* %70 + productivity index (PrI) + location index (LI)

These indexes change 0 to 100 for soil, 0 to 10 for productivity and 0 to 20 for location.Soil index is determined after laboratory analyses and sampling technique is used. Productivity index map is obtained after laboratory analyses and agricultural statistics.
To find out location indexes of plots, it is important to take into account those; distances to residential centre, to road, to irrigation network, to power line and to flood plain area etc.

2.3 Formation of Blocks (water management, drainage and road systems)

Application projects of infrastructures and superstructures, which were previously planned by private or governmental foundations in the project area, have to be agreed with land consolidation projects. After the completion of irrigation, drainage, road, grading and ownership etudes, blocks are formed on Standard Topographic Cadastral Maps by drawn irrigation, drainage and road plans. While forming the blocks, length and direction of irrigation, grading state, rate of wide and length of plots must be known and taken into consideration.

2.4 Determination Of Stationary Establishments

Stationary establishments such as House, barn, hayloft, working well, vineyard, olive grove, pistachio grove, fruit grove, poplar grove, sandpit, stone yard, etc. are determined in the field and marked on maps. These stationary establishments must be described immediately at the time of classification by the classification commission.

3. HIGH RESOLUTION SATELLITES

The strong improvement in space-borne data and consequently in the reference scale, can be evaluated by considering the following features:

- from 1 (Ikonos) to 0,61 m (Quick Bird) of panchromatic resolution at nadir
- from 4 (Ikonos) to 2,44 m (Quick Bird) of multi-spectral resolution at nadir
- simultaneous panchromatic and multi-spectral acquisitions
- radiometric range of 11 bits (2048 levels of grey) instead of the usual 8
- panchromatic band ranging from blue to near infrared

The two last characteristics in particular enable, through a proper spectral and radiometric enhancement (vs. analogical air photos e.g.), to reach a better contrast, visibility and information content and then a better target distinction (Rossi, 2003).

3.1 QuickBird

Main requirements to be satisfied in order to use QuickBird data as a source of information for land consolidation, agricultural and forestry applications can be identified as follows:

- High geometrical resolution (for large scale projects)
- Multispectral capabilities
- Radiometric sensitivity
- Good positioning accuracy
- Revisit capabilities
- Large image size

Quickbird highlights can be summarized as follows:
Good geometrical resolution - QuickBird data has a native resolution of 0.61-meters when collecting at nadir that become 0.66- meters when collecting with an acquisition angle of 15°. Since 90% of the frames collected by QuickBird have a collection angle in the range 0°-15°, the geometrical resolution can be easily compared with the one resulting from an average scale aerial flight.

Multispectrality – QuickBird collects the frame on a higher resolution panchromatic band extended also in the near-infrared, and on four multispectral bands (three in the visible, one in the near infrared). By using data fusion techniques, the multispectral bands can be merged with the panchromatic, in order to obtain the best high resolution pansharpened, but in natural or in false color.

Radiometric sensitivity – QuickBird data has a 11-bit dynamic range (2048 levels of grey), therefore they can be stretched in specific data range in order to improve the visual information. This feature is very useful when dealing with urban shadowed areas.
Good positioning accuracy – QuickBird data can be geometrically processed with different techniques:

- Ortho-rectification with a rigorous sensor model
- Ortho-rectification with the RPC (Rational Polynomial Coefficients)

The first approach is possible since the Basic QuickBird product packaging includes not only the image file, but also a list of ancillary data files, such as those containing the ephemeredes and the attitude parameters. These data, managed by a proper software that models the satellite sensor, enable the generation of accurate ortho-images. Software packages that can handle the rigorous QuickBird sensor model are already on the market.

Revisit capabilities - The satellite has a reviewing rate that depends on the off nadir angle. In any case, applications that require multitemporal observation with a seasonal frequency can be easily carried out with QuickBird data.

Large image size – When collecting with an off nadir angle in the range 0°-15°, the QuickBird image covers approximately a swath in the range 16.5 – 18.0 km. Therefore, the extension of each frame is roughly 270 up to more then 300 sqkm. Given this frame extension, is possible to collect an image over municipality groups (useful for instance in subsidies control samples)

For the above reasons, currently, using satellite data is possible to define the classical parameters usual for traditional interpretation such as in air-photos interpretation as follows:
- tone and texture for single targets
- shape (e.g. for trees, crown, pruning etc.)
- distance and target geometry
- context identification (through different human activities identification)
- multi-spectral analysis of single objects instead of groups of pixel

In addition it is possible:
- updating of the data base when necessary;
- date selection for the best period of acquisition, both from archive and through planning (e.g. based on phenological phases or natural events);
- easy image processing in order to create image fusion (pansharpened)

3.2 IKONOS

The Ikonos-2 satellite was launched in September 1999 and has been delivering commercial data since early 2000. Ikonos is the first of the next generation of high spatial resolution satellites. Ikonos data records 4 channels of multispectral data at 4 metre resolution and one panchromatic channel with 1 metre resolution. This means that Ikonos was the first commercial satellite to deliver near photographic high resolution satellite imagery of anywhere in the world.

IKONOS imaging system, present three different products: 1-meter Panchromatic (Pan), 4-meter Multi-spectral (MS), 1-meter Pan-Sharpened (PSM). Pan-Sharpening combines the spatial content of the 1-meter panchromatic data with the spectral content of the 4-meter multi-spectral data. The final product gives a "color" image at 1-meter resolution, but the MS radiance values are changed and therefore the product is no longer suitable for automatic classification (Samadzadegan et.al,2003).

Radiometric Resolution: Ikonos data is collected as 11 bits per pixel (2048 gray tones). This means that there is more definition in the grey scale values and as a viewer you can see more detail in an image. In order to benefit from this additional information, it is required specialist image processing software.
Ikonos has both cross and along track viewing instruments which enable flexible data acquisitions and frequent revisiting capabilities - 3 days at 1 metre resolution and 1 to 2 days at 1.5 metre resolution.

	Band Width	**Spatial Resolution**
Panchromatic	0.45 - 0.90µm	1 meter
Band 1	0.45 - 0.53µm (blue)	4 meters
Band 2	0.52 - 0.61µm (green)	4 meters
Band 3	0.64 - 0.72µm (red)	4 meters
Band 4	0.77 - 0.88µm (near infra-red)	4 meters

4. OTHER SATELLITES

4.1 LANDSAT 7

The earth observing instrument on Landsat 7, the Enhanced Thematic Mapper Plus (ETM+), replicates the capabilities of the highly successful Thematic Mapper instruments on Landsats 4 and 5*. The ETM+ also includes new features that make it a more versatile and efficient instrument for global change studies, land cover monitoring and assessment, and large area mapping than its design forebears. The primary new features on Landsat 7 are:

- a panchromatic band with 15m spatial resolution
- on board, full aperture, 5% absolute radiometric calibration
- a thermal IR channel with 60m spatial resolution

4.2 SPOT 5

Following SPOT 4, the SPOT family provides service continuity with SPOT 5 for which CNES is designing a new imaging instrument High Resolution Geometry or HRG. SPOT 5 offers new capabilities and performance to answer the growing demand in cartography, agriculture, planning and environment.

SPOT 5 was placed by Ariane in the same orbit as SPOT 1, 2, 3 and 4, i.e. a circular, quasi-polar orbit at an altitude of 830 km and a pass over the equator at 10.30 a.m. (local time at descending node).
The main payload consists of high resolution imaging instruments delivering the following product improvements compared to SPOT 4:

- higher ground resolution: 5 meters and 2.5 meters (instead of 10 m) in panchromatic mode,
- higher resolution in multispectral mode: 10 m (instead of 20 m) in all 3 spectral bands in the visible and near infrared ranges. The spectral band in the intermediate infrared (essential for Vegetation data) is maintained at a resolution of 20 m due to limitations imposed by the geometry of the CCD sensors used in this band,
- field width of each instrument: 60 km,
- the oblique viewing capacity of each instrument is maintained, providing rapid access to a given area,

- dedicated instrument for along track stereo acquisition,

The Spot 5 spectral bands are the same as those for Spot 4. The panchromatic band does, however, return to the values used for Spot 1-2-3 (0,51 - 0,73 µm). As requested by many users, this ensures continuity of the spectral bands established since Spot 1. Spatial resolutions are, on the other hand, improved within the limits of technical feasibility as the field width of each instrument will be also kept identical.
HRG sensors:
Two HRG (High Resolution Geometric) instruments are capable of generating data at four resolution levels with the same 60 km swath:
- images in the SWIR band: 20 m
- multispectral images (green, red and near-infra-red): 10 m
- panchromatic images : 5 m
- supermode panchromatic images: 2.5 m

5. HIGH ACCURACY LEVELS TO BE OBTAINED FROM SATELLITE IMAGES

Now it is possible to generate the thematic maps on various scales ranging from 1:2500 and 1:1,000,000 scales keeping in view the end users requirement. The locational accuracy of maps is utmost important for certain applications like Cadastral survey, infrastructure/utility maps, Urban land use, Land planning and Land consolidation works etc. Using one-meter resolution imagery and GPS controls, it is now possible to achieve an accuracy of +/- 2 meters. It will be appropriate here to discuss the technical lag between the large-scale topographic maps on 1:25,000 scale and the utilization of information provided by finer resolution (around 1 meter) offered by recently launched satellites. The utility of remotely sensed derived information/maps, especially from finer resolution satellites can be described in the context of National Spatial Data Infrastructure. The application and mapping potential of very high resolution data like IKONOS, Cartosat etc. is now encourage us to use them in several projects of different purpose. Some projects studied by researchers demonstrated the mapping potential of the finer resolution imagery. Results from such two pilot studies on Large scale mapping using IKONOS (1 Mt) data represented in Ghosh's paper (2003) suggest 6 m and 2 m locational accuracy taking controls from 1:25,000 scale map and GPS based points respectively. These studies also proved that one could go up to 1:2500 scale thematic mapping such as urban land use.

From the results in the literature and obtained with the simulated satellite images covering a established test field, some encouraging conclusions were drawn about the mapping potential of this high resolution satellite image system. The accuracy of ground points can reach 3m in planimetry and 2m in height with over 4 GCPs (Ground Control Points) in spite of fact that the experimental conditions were based on a simulated study. Therefore, significantly more than four GCPs are not recommended in order to maintain high accuracy and minimize costs. A distribution of GCPs along a straight line especially across the track is not useful for increasing the accuracy of ground points. A well spared distribution of even a few GCPs is more beneficial to accuracy improvement than a dense but poorly spread distribution. The one-meter resolution imagery will meet accuracy requirement for medium-scale topographic mapping at scales from 1:24,000 to 1:10,000. (Li et. al, 2003)

In other study, it was represented that IKONOS imageries can only supply the data for a preliminary or provisional revision of 1:5000 scale topographic maps or for the rapid but incomplete revision of existing maps at this scale. Regarding the tests carried out in this project the IKONOS data seem to be rather deficient in providing the complete details required for the production of a final edition of a 1:5000 scale map or for the comprehensive revision of an existing published map at this scale. These deficiencies are particularly apparent with regard to the buildings and small man-made structures. In order to overcome these deficiencies, which could be as high as 25% of the total map content in urban areas, a complementary field work is necessary. The overall evaluation, by taking both geometric stability and the information content of the image, seems to indicate the feasibility of a complete map revision process for the scale of 1/10000 using IKONOS Geo-panchromatic images (Samadzadegan et. al, 2003).

6. ADVANTAGES FROM THE USE OF SATELLITE IMAGES IN THE PLANNING STAGE OF LAND CONSOLIDATION PROJECTS

Average sizes of land consolidation projects change between 500 to 1000 hectares in Turkey (Archives of rural land general administrator, Anonymous, 2000). With a smallest IKONOS image of 1 m field resolution in 10 x 10 km^2 (10000 hectares), it might be covered at least 5 village's lands in a land consolidation projects according to the given value above. In this case, consolidation works of all villages appeared in the satellite image can be done all together or in a most convenient time later village by village over the same satellite image.

In a land consolidation work, maps, which are used as base maps, are;

- 1/5000 scale cadastral maps and
- 1/5000 scale topographic maps.

Present cadastral maps, which have been produced in Turkey, have not been updated yet and some of them are even 40-50 years old, can be updated from satellite images by matching them with these present cadastral maps for the determination of present details on the field such as roads, buildings, irrigation networks and etc. which do not exist on the old cadastral maps. Similarly, topographic maps, which are used to plan irrigation and road networks and land classification, can be updated or produced from satellite images even if they do not exist.

Here should be answered a question such as, if satellite images can give an accuracy, which topographic and cadastral maps in 1/5000 scale provide. As it is given in the specifications of the satellites provided above, precision of PAN bands of some satellites such as IKONOS and QUİCKBİRD is in 1 m and even reaches to 0.61 m (Rosi, 2003). Accuracy obtained from digitized cadastral and topographic maps changes between 1 – 2 m according to the some research results (Cay et.al. 2003). Thus, one can come to the conclusion that these two accuracies can match well. It can be said that it can be obtained even a better accuracy from satellite images.

The use of satellite images for soil maps:
They can be determined from satellite images the distances to settlement center, road and irrigation network, power line, flood plain, which are effective factors for the formation of location indexes of plots. Since the accuracy requirement for the determination of these factors is 5 to 10 m, it can be used satellite images, which are less accurate, but cheaper than finer one if the finer one does not exist previously.

Cost of map production from satellite images:
The cost of a stereo IKONOS satellite image of 1 km^2 is about 118 dollar in Turkey. Although, it is adequate to use 3-5 control points to register a satellite image. It is necessary to establish homogeneously distributed 6 control points for application, detail measurements and etc. in the case of a classical geodetic measurement process to be carried out in a field in the sizes of 10 * 10 km, which is covered by an IKONOS image of the smallest size to be obtained. The number of control points, which is more than required for the registration of a satellite image, will even give better accuracy than those from satellite image registered by 5 control points. Extra control points can be used for geodetic works probably to be carried out in the other stages of land consolidation. One control point costs about 2407 dollars for the first half of the year 2003 with respect to the prices suggested by Chamber of Surveying and Cadastral Engineer in Turkey.

Activities	Personals	Unit Cost ($)	Total Cost ($)
Establishment, planning and calculation processes of Control Point	1 Surveying Engineer 1 Surveying Technician 6 Control Points (by GPS observation)	2407	14442
Obtaining satellite images, rectification, chose and calculations of map projection, evaluation of satellite images	1 Surveying Engineer (30 day) 2 Surveying Technician (30 day)	63 42	1890 1260
Satellite Image	10km * 10 km	118	11800

1 dollar ($) = 1400000 TL   Cost = 29392 $
Company profit and other expenses= 15000 $
Total Cost = 44392 $

Cost of 1 hectare = 44392/10000 = 4.44 $/hec

Detail measurements to be carried out in an area of 1 hectare will cost 149.66 dollars, according to the prices suggested by Chamber of Surveying and Cadastral Engineer in Turkey for the first half of the year 2003 if classical measurement techniques are used. These classical measurements for the whole mission area of 10 x 10 km can be completed at least in three – four months. Production of the map by satellite images can be completed in one and half months after the obtaining of satellite images.

Land slope maps can be obtained from software that uses satellite images to evaluate and do several analyses. Thus, these maps can be used as base maps when the irrigation network is planned for the region. It can also be utilized from satellite images in the production of hydrographic maps for the planning purposes.

Constructed irrigation and road networks in the planning stage essentially form the blocks, which are subject to the distribution, as well. When the land constellation blocks constituted on maps are applied to the field, 1 – 2 m differences can appear at the block corners that are contrary to the land features which actually describe the original block edges and corners in the field, if the block corners are got from the maps produced by using satellite images and remote sensing software. In the land consolidation works carried out by using classical measuring techniques, some arrangements for the differences, which extent to 3 m and appear during the application and control measurements of the blocks, are actually done to fit to the original features on land. For this reason, road and irrigation networks and block edges are shifted to fit the digitized and computed values of the block corners and edges to the original features on land. From these two cases, it can be suggested that results from satellite images show better accuracy level with 1-2 m errors than those from classical techniques.

Similarly, in a land consolidation project, it is important to determine the stationary establishments and facilities on land such as bridges, fruit gardens, buildings, houses, power lines and etc. for distribution of blocks and for classification to be done in the region. Since classification and distribution works get difficult, when these stationary establishments and facilities do not exist especially on the present cadastral and topographic maps. Another important issue to be mentioned here is that it is mandatory to assign the stationary establishment or facility on the land consolidation field to its original owner during the distribution stage of the consolidation work. Satellite images beside give an ability to determine those stationary establishments and facilities and they also provide a medium where the determination can be done very rapidly. Thus delays in the project procedures and processes can then be avoided mostly.

7. CONCLUSIONS

In the planning stage of a land consolidation work;

- Determination of present state of project area,
- Land works and classification processes,
- Formation of blocks (water management, drainage and road systems),
- Determination of stationary establishments

can easily be done in the required precisions by using satellite images. In the case of that land consolidation activities explained above is done by using satellite images, they can be completed in half of the time that classical techniques require and the project can cost 35 times cheaper than that the classical techniques cost.

When cadastral, classification and satellite images are put one right after the others by matching the features, which appear on all of them, the fields which are not registered and can not be seen on cadastral maps can easily be determined during the land consolidation work together and registered to national treasury. After all, in the next step, they can be evaluated under the cover of land reform and distributed to the farmers who are not the owner of farmland. At the same time, government also has a financial source from these earned fields.

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