Orthophoto Information System in Turkey in the View of Spatial Data Infrastructure

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Abstract: *Spatial technologies are evolving quickly, particularly with regard to land related data. The design of land information system needs to be efficiently comprehensive to take these into account and manage them through a Spatial Data Infrastructure (SDI). The most effective management with the technological trends is likely to lie in spatial enablement of the various sets of information. SDIs aim to facilitate and coordinate the sharing of spatial data between stakeholders, based on a dynamic and multi-hierarchical concept that encompasses the policies, organizational remits, data, technologies, standards, delivery mechanisms and financial and human resources necessary to ensure that those working at appropriate (global, regional, national, local) scale. Satellite images and/or aerial photographs, which are one of the indispensable layers of spatial information systems, are quite important in the context of National Spatial Data Infrastructure (NSDI). This study overviews the Photogrammetry, Orthophoto production studies and Orthophoto Information System (OIS) in Turkey within the scope of SDI.*

Keywords: *SDI, photogrammetry, orthophoto, map production, interoperability.*

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1. Introduction

The term Spatial Data Infrastructure (SDI) was coined in 1993 by US National Research Council. It is defined as totality of "technology, policies, standards, human resources and related activities necessary to acquire, process, distribute, use, maintain and preserve spatial data throughout all levels of government, the private and non-profit sectors and academia. Also, SDI concept is a core infrastructure supporting economic development, environmental management and social stability in the countries [21]. Since, the 1990s, SDIs have been developed all over the world to facilitate the use of spatial data in different sectors and also at different levels such as: Local, regional, national and global scales [2, 23, 24, 28]. SDIs have economic, social, technical and environmental benefits and they have the potential to spatially enable governments to provide better service to decision-makers, politicians and societies [17, 25, 27].

Turkey is moving towards a spatially enabled society underpinned by a national geo-SDI, called Turkish Spatial Data Infrastructure (TNSDI). Initial studies about TNSDI concentrated on the Infrastructure for Spatial Information in the European community directive (INSPIRE). TNSDI aims to reach true and actual geographic information in national standards online for geographic information users and decision makers. The principles of TNSDI project are to establish Geographic Information Systems (GIS) infrastructure accordance with INSPIRE directive, to create a web portal for geographic information produced by government agencies and to determine the standards of the data. Until July 2011, The General Directorate of Land Registry and Cadastre (GDLRC) under the abolished Ministry of Public Works and Settlement had been responsible for the initial National Spatial Data Infrastructure (NSDI) studies and coordination [13, 14, 29, 30]. After organizational studies among institutions and commissions on NSDI in Turkey have been executed under coordination of GDLRC, General Directorate of Geographic Information Systems (GDGIS) is established under the Ministry of Environment and Urban Planning with the Decree numbered 644 that are published on the Official Gazette dated as 04.07.2011. The main duty of this general directorate is to establish, use and develop national geographic information systems and to make and to support the studies and processes for this aim. Now, GIS and SDI studies have been continuing under the control and leadership of GDGIS [12].

INSPIRE Directive aims to establish an infrastructure for spatial information in Europe to support community environmental policies, and policies or activities which may have an impact on the environment. The directive addresses 34 spatial data themes (in annex1, annex2 and annex3) needed for environmental applications [18]. Orthoimagery is situated in Annex2 of INSPIRE directive under the structure of the themes. Orthoimagery is a geo-referenced image data of the Earth's surface, from either satellite or airborne sensors. An orthoimage is a raster image that has been geometrically corrected (orthorectified) to remove distortion caused by camera optics, camera tilt, and differences in elevation [19].

In this study photogrammetric studies and orthophoto (aerial photographs geometrically corrected) production procedure in Turkey are explained within the scope of NSDI.

2. Photogrammetric Studies in Turkey

If the definitions are customized, the geometrically corrected raster image obtained from airborne sensors is called as "orthophoto", the geometrically corrected raster image obtained from satellites is called as "orthoimage". The aerial photos are basic sources for orthophoto production. One of the methods to produce spatial data and spatial data set as defined in SDI environment is "Photogrammetry". Photogrammetry is the science, technology and art of making measurements from photographs. It is a method to collect true and reliable data fastly. Furthermore, it provides visual information wealth after integration of real maps and image of earth surface [29].

Evinay declares [8] that the initial photogrammetric studies are realized between 1932 and 1936 in Turkey. He categorizes the photogrammetric studies in terms of technic, character and efficiency as 1932-1936 first phase, 1938-1950 second phase, and 1950-1959 third phase. Since, 1950 the photogrammetric method has been used for land related works [4]. In 1955 Department of Land and Photogrammetry is established for cadastral works. In the years of 1957 and 1958 the identification photographs are realized by drawing the parcel boundaries on these aerial photos, however they cannot be transformed to the cadastral plans. Therefore, standard stereo-evaluation method is applied and 1/5000 scaled photogrammetric maps are produced. Finally, they are integrated to the field works as cadastral maps [28]. The use and expanding process of the photogrammetric systems have experienced very rapidly. Until 1985 analogue data collection tools are used for the production of the topographic linear maps. 1988 is the starting date for the analytic data collection for photogrammetric triangulation. In 1996 the digital photogrammetric systems are purchased and after 2000 the digital photogrammetric production has begun. End of the 1990s marks the beginning of the production of the digital maps and the orthophotos [7]. General Command of Mapping (GCM) and GDLRC are the government agencies that have aerial cameras, stereo-evaluation station works, software and server [1, 9, 16]. Also, GCM serves the aerial photographs online [10].

3. Turkish National Orthophoto Information System

Turkish National Orthophoto Information System (TNOIS) is one of the studies in Council of Coordination and Planning of Inter-ministerial Map Works (CCPIMW) that is established in 1983 according to the GCM Law[1]. Commission of Scientific Research and Coordination (CSRC) which is one of three commissions in CCPIMW gets on the agenda TNOIS at general assembly in 2008. It is appointed that CSRC will receive corporate vision through Orthophoto Information System (OIS), determine needs and demands in 2008. The research within this context shows that about 95% of the government agencies need this system. Also it is stated that:

- Many institutions/organizations need satellite image or aerial photographs
- Repeated requests are reported to Under Secretariat of State Planning Organization (USPO) because the lack of enough coordination among the institutions/organizations
- Waste of the country's resources will be because of the repeated requests
- The cost of satellite-image requests will be high, however these requests will be met with the updated aerial photographs
- For well-coordination, the organizations which have aircraft and digital airborne camera may take images, and also extra aircraft and camera may be bought with financial support of USPO, the taken images may be stored in a system to share with all authorized organizations.

Finally, in general assembly of CCPIMW in 2009 it is decided that a project will be prepared on OIS. The capabilities of OIS should provide efficient usage of country resources, avoid repeated taking photos, access the images easily, provide standardization and update for aerial photographs [22, 25].

- Preliminary Review and Statistics: CSRC decides to collect information for future works on OIS and prepares information collection form. These forms are sent to 19 member organizations of CCPIMW, 16 non-member organizations, 8 universities and 3 great metropolitan municipalities. The forms received from 29 organizations, 2 universities and 2 great metropolitan municipalities are evaluated. According to the filled forms the statistics show that utilization rate of the aerial photographs for the spatial data production and decision supports on spatial data is %17 as shown in Figure 1. Figure 2 illustrates the usage areas of the satellite images and aerial photographs. Figure 3 shows the detailed usage areas of the aerial photographs; Figure 4 shows the detailed usage areas of the satellite images. The time period for the need of the aerial photos is demonstrated in Figure 5, the preferred spatial resolution is in Figure 6. %96 of the forms says that they believe their organization will use OIS with the conditions of taking of the photos of the entire country, producing the orthophoto, updating at regular intervals and authorizing the organizations. The rest rate (%4) has no idea [3].

[1]General Command of MappingLaw. Law No: 657, OfficialGazette No: 99, OfficialGazetteDate: 02.05.1925.

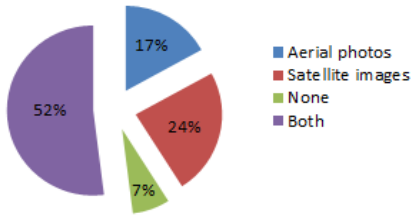

Figure 1. Tools for spatial data production and decision makers.

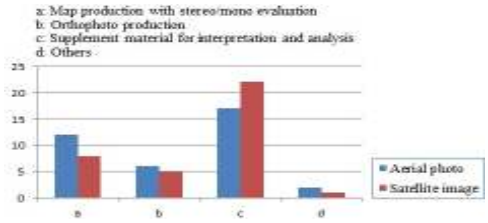

Figure 2. Usage areas [22].

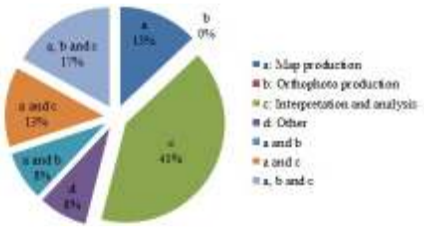

Figure 3. Usage areas of aerial photos [22].

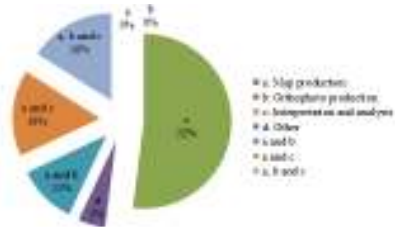

Figure 4. Usage areas of satellite images [22].

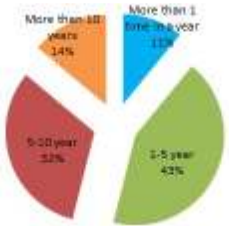

Figure 5. Time periods for the need of aerial photos [22].

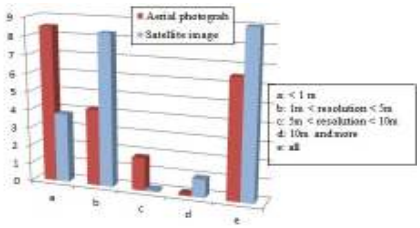

Figure 6. Preferred spatial resolution [22].

After the initial research in 2008 it is decided that 90% of the organizations need a system for orthophoto. Based on the results of this study the duty to prepare a project for OIS is assigned to CSRC in general assembly of CCPIMW. The studies are started on 1 April 2009. Finally, a feasibility report is prepared and presented to ministry of development for investment program. However, the report is revised as GDGIS instead of Ministry of Development because GDGIS is established on July 2011and the report is overlapped with the duties and the authorities of GDGIS. Also, the feasibility report is revised by GDGIS. The report determines that the organizations need the orthophoto which have 1/5000 scale and 20-30cm resolution. Besides production program and production period are investigated for local governments such as municipalities. It is identified that the orthophoto which have 1/1000 scale and 8-10cm resolution are needed for planning and zoning facilities and digital geographic data production in urban areas.

According the interviews with the organizations under the control of GDGIS and in the scope of NSDI it is determined that orthophoto data theme in annexes of INSPIRE Directive have been used by 12 ministries, 22 general directorates, 24 departments and in 73 works. While realizing the works 58 different legislations and 49 orthophoto data layers (after combining the repeated layers) are used. 84% of these organizations are users of these layers, 4% are producer and 14% are both user and producer [11].

- Current Situation: According to the analysis results of CSRC in 2009, 35 cities of 81 cities in Turkey have the orthophoto 1/1000 and 1/5000 scaled. 14 of these 35 cities have only the orthophoto 1/1000 scaled, 9 of them have only the orthophoto 1/5000 scaled and 12 of them have the orthophoto both 1/1000 scaled and 1/5000 scaled. 11 cities have both orthophoto and satellite images. In Turkey legal authorization to take aerial photos and produce maps from these photos belongs to GDLRC and GCM (1/5000 scaled and higher ones to GDLRC, smaller than 1/5000 scaled ones to GCM). These aerial photos and maps are requested by other organizations and used legally. 24857 orthophoto sheets 1/5000 scaled cover 18% of entire country as shown in Figure 7 [25]. As shown in Figure 7, the production in 2010 is much more than the other years because of Land Parcel Identification System Project (LPIS). General Directorate of Agricultural Reform (GDAR) aimed to digitize the agricultural land blocks by using orthophoto 1/5000 scaled in the scope of LPIS project and received finance through Instrument for Pre-accession Assistance (IPA) under Turkey-EU financial cooperation relationship.

Figure 7. Current orthophotos 1/5000 scaled according to the production years [25].

GDLRC have been continuing to produce 1/5000 scaled digital colour orthophoto for itself and other organizations to be basic for SDI projects. It has experienced staff, 1 airborne that DMC digital camera is installed supported with Global Positioning Station (GPS)/IMU, 100 terabyte storage, hardware and software for flight plan, GPS/IMU calculations, digital image processing, photogrammetric triangulation, Digital Elevation Models (DEM), stereo-evaluation, orthophoto production and also hardware and software for image web service. In case GDLRC uses the private sector facilities for geodetic studies, photogrammetric triangulation studies, DEM studies and orthophoto production studies GDLRC staff work as project executer, consultant and controller on these studies for accuracy, quality and time control. Taking aerial photos, evaluation of GPS/IMU data, digital image processing steps are done by GDLRC [20].

GDLRC planned and completed orthophoto maps of 68000 km2 area which has 30 m spatial resolution in 2010. It performed service purchases for 3 regions in 2011 and completed in 2012. In 2012 4regions are planned, 2 regions of them are realized by the service purchase from the private sector. In 2011 a protocol was signed between GCM and General Directorate of National Property (GDNP) for orthophoto production of the determined regions which cover 40000 km2 areas with 30 cm Ground Sample Distance (GSD). Under this study 65450 orthophoto map sheets scaled 1/5000 (47% of entire country) was planned and completed. 35% of whole Turkey is not planned and has no orthophoto yet as shown in Figure 8 [25].

Figure 8. 1/5000 scaled orthophoto production by GCM (HGK) and GDLRC (TKGM) which is planned and completed in 2012 [25].

59000 orthophoto sheets are produced in 1/1000 scale as shown in Figure 9. The number of orthophoto is high in 2007 because of orthophoto studies in Istanbul city and in 2010 because of orthophoto studies in Kocaeli and Bursa cities. In 2012 it is planned to produce the orthophoto in Aydin, Bolu, Istanbul, Kutahya, Mugla, Trabzon and Batman cities, especially for whole area of Istanbul and urban centres of the other cities.

Figure 9. 1/1000 scale orthophoto production according to the years [25].

GDLRC achieves the orthophoto and also their products. The orthophoto in GDLRC are prepared in Open Geospatial Consortium (OGC) standards and served by orthophoto web services to the authorized organizations. For example, the orthophoto are presented to cadastre offices in the cities to visualize the photos by overlapping the cadastral drawings and integrating the registration attributes. This system called MEGSIS (Spatial Real Property System) is an application that aims to integrate. Cad format data (cadastral parcels) in local computers of cadastre offices with the attributes of these data in land registry offices and then to serve them to the stakeholder organizations, institutions, agencies and municipalities via web services. One of the services of MEGSIS is orthophoto services which present 1/5000 scaled orthophoto in Tile Map Service (TMS) by support of open source GDAL library [15]. This system is used to control cadastral parcels obtained by digitizing and surveying. It is used on decision support and control level of the cadastral renovation studies. An external access (out of GDLRC) for authorized and a stakeholder organization is provided by static IP control for the system security. During field studies access to the orthophoto web service is possible with notebooks and GPS receiver unites.

4. Discussion

The orthophoto present up-to-date situation of the field, inform the geometric accuracy of the map with a photograph, facilitate the difficulty of the display of the complex field structure and land cover, give much more information than vector map as geologists, agriculturists and planners need. The basic usage areas of the orthophoto are environmental monitoring, agricultural applications, geographic referencing, monitoring natural phenomena such as floods, land planning and land management. "Orthophoto/ orthoimage" is one of the most important layers of GIS. Thus it is aimed that the orthophoto will be one of the outputs of NSDI. "Orthophoto" data theme may be used to obtain the objects some other data themes such as topography and hydrology. It related to "Coordinate Reference System (CRS)" data theme, because CRS contains all coordinate systems and all other related things. Also this theme is the basic with the other themes to create thematic maps.

The initial feasibility studies to determine NSDI standards indicate that the large or small scaled topographic maps cannot meet the need of the basic map. Besides organizations/government agencies don't have the opportunities to get satellite image or aerial photos when they need. Even in case these are obtained there is a workload such as geometric correction processes, technical processes of Ground Control Points (GCP) and DEM. Therefore, these processes generally cannot be made with the accuracy that is

technically possible or updated map production has a hitch because there is a need for important resource investments to increase the accuracy. Finally, the lack of updated map and legal infrastructure causes many investments cannot be realized in a timely or accurate manner. Nowadays, Google-Earth and Google-Maps have been used as a basic document, data quality assurance cannot be provided, and these data cannot be used for official processes. While the use of Google-Earth and Google-Maps has been increasing, there is no guarantee for the use in future. Therefore, it is expected to produce the map related data/information with high resolution from orthophoto and serve them to the organizations/institutions/agencies. For this purpose one of the main data themes of NSDI and also TNSDI is "orthophoto data theme".

According to the analysis which organizations use/produce aerial photos and their products the prominent government agencies are GDLRC, GCM, GDAR, General Directorate of State Hydraulic Works (GDSHW), General Directorate of Forest (GDF), General Directorate of Spatial Planning (GDSP), GDGIS, General Directorate of Infrastructure and Urban Transformation (GDIUT) and local administrations (municipalities). GDLRC aimed to produce and use 1/5000 scale digital color orthophoto for cadastral renovation studies planned in 2007. All orthophoto produced for this goal has the quality that meets the needs of the other organizations/agencies. GCM needs stereo aerial photos and orthophoto 1/25000 scaled for defensive purposes, produces ones 1/5000 scaled for the needs of the other organizations. GDAR needs the orthophoto for LPIS to digitize agricultural land blocks from orthophoto. GDSHW needs and uses them for irrigation, dam, drinking water facilities and DEM. Approximately 27% of whole Turkey is covered by forests. GDF needs stereo aerial photos and orthophoto for planning studies of forest areas and forest cadastre with 1/25000 and 1/5000 scales. GDSP needs the orthophoto 1/1000 scaled to determine urban development, to monitor land use, to prepare spatial strategic plans, to plan coasts, to determine shoreline, to determine disaster prevention plans and rural plans. The orthophoto 1/5000 scaled are needed for other applications. GDGIS needs the orthophoto 1/1000 scaled and their DEM for the production of geographic data sets in the INSPIRE data themes and residential areas. GDIUT needs the orthophoto 1/1000 scaled to determine and plan urban transformation areas in the residential areas, local administrations need them for planning, zoning and construction facilities.

Orthophoto are cheaper than the orthoimage although, both of them have the same procedure steps such as: GCP establishment, DEM production, and orthorectification and mosaic king. The main cost determinant is the unit area cost of digital aerial photo or the cost of the taken satellite image. Satellite images are licensed and priced as single or multiple use. The recipient cannot use them out of the rules in the license agreement and cannot share them with others. This causes the same or alike data is bought by different organizations repeatedly with a huge budget. OIS will provide the possibility to get the different clear aerial photos and their products whenever required, and provide more benefits by removing financial and technical concerns on pricing and sharing. On the other hand satellite images don't have the poisoning accuracy as the orthophoto 1/1000 scaled. However, the use of the photogrammetric products instead of geodetic methods for geographic data production for NSDI will provide high speed and low cost.

Besides all of these OIS is an example of interoperability among the organizations, institutions and government agencies because of being a basic infrastructure for all data layers.

The geospatial data obtained from aerial images are used for different purposes by different sectors. Geospatial databases hold a variety of natural and man-made objects. Prasad and Ramakrishna [26] use the aerial images for an efficient traffic forecasting system. GIS and Multi-Criteria Decision-Making (MCDM) techniques are two common tools to solve the spatial-based problems [5, 6] and it is clear that the extracted geospatial data from aerial photos/images is one of the main data source for these aims.

5. Conclusions

The use of spatial information is undergoing a revolution. Historically spatial information was the exclusive technology of surveyors, cartographers and later GIS professionals. Today spatial information is increasingly being used in a ubiquitous and transparent manner by government and wider society across most activities and business process. The use of spatial information has the impact of digital world. The vision of spatial enablement requires an enabling platform or infrastructure using SDI concept linked to modern land administration systems. One of the required spatial data themes of SDI is "orthophoto/orthoimage".

Orthophoto maps combine all advantages of conventional line maps and aerial photography. The photographic background is rectified to remove image displacements and enlarge to a scale. Orthophoto may have a specific role which comprises the extraction of thematic information, as well as mapping and monitoring of the environment. Also the "orthophoto" is the basic spatial data and layer for all land related projects and organizations/institutions/ government agencies. Interoperability is indispensable feature of this study.

Production of spatial data is still in progress in Turkey. The studies on Turkish National SDI have been executed through INSPIRE Directive which is an infrastructure of spatial information in Europe for

purposes of community environmental policies and the policies or activities which may have an impact on the environment. SDI is urgently needed to better understand the complex interactions between natural and human systems and to be better prepared to address the emerging consequences of environmental challenges.

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