Role of Geo-Informatics in Scientific Development: A Review of Pakistani Experience in Space Sciences

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Abstract: Geo-informatics (GI) is a recently coined term which is a collective acronym being interchangeably used for the fields of Remote Sensing, GIS (Geographical Information Science), GPS (Global Positioning System), Photogrammetry and Surveying. Though Geo-informatics is a modern emerging field in Pakistan, nevertheless, its roots dated back to1950s when first aerial photograph was used in Hunting Survey under Colombo Plan [4]. This was the time when digital computers and space satellites were in their initial phase of development in few developed countries like USA and Former USSR. During 1960s, Space Science with the advent of manned and unmanned satellites opens new avenues of pragmatic applications for GI in many fields of science, especially earth sciences. In 1970s, Remote sensing along with GIS becomes a highly applicable science in the world and to some extent in Pakistan as well. The birth of Personal Computers (PCs) in early 1980s, significantly contributed in the development of geo-informatics which multiplied its growth in 1990s with the introduction of internet and GPS (Global Positioning System). This was further reached on its climax in 2000s, when very high resolution data were cheaply available around the globe. During all these above-mentioned phases, various institutes and individuals in Pakistan used this new tool to address complex issues, both in public and private sectors. Unfortunately, nothing has been published to document these isolated and un-coordinated efforts. Although Alizai and Mirza [1] and Ali [12] summarized the gist of the activities in Pakistan but their focus were mainly the activities functioning only in Space and Upper Atmosphere Research Commission (SUPARCO) of Pakistan [18]. Therefore, this paper is an attempt to review the activities of geo-informatics to determine its role in scientific development of Pakistan at a broader canvas encompassing at large both private and public sectors; and to further discover viable opportunities for interested scholars in various fields of science in upcoming future.

BACKGROUND

Geo-informatics is the science and collection of technologies which develops and uses information science infrastructure to address the problems of geography, geosciences and related branches of engineering [19]. Its domain is covering, mainly, the fields of Remote Sensing, GIS, GPS, Digital Cartography, Photogrammetry and Surveying. Pakistan has seen the waxing and waning of GI fields, since its independence in 1947. Pakistan is a country with full of natural resources, these resources are being threatened by various natural calamities and illegitimate human interventions. Therefore, Pakistan essentially needs a Sustainable Resources Development Programme to conserve its decaying resources. For this purpose, mapping and monitoring of existing natural resources and forecasting of the future scenarios is highly critical. In this context, GI plays a significant role in providing geo-information on compatible spatial formats. It would also assist in determining, enhancing and monitoring the overall capacity of the valuable resources found in various ecosystems of Pakistan. Satellite observations of land, oceans, atmosphere, and specifically, during natural and human-induced hazards have become crucial for protecting the global environment, reducing disaster losses, and achieving goals of sustainable development. GI using space-borne satellite remote sensing sensors, as a tool, is highly effective for obtaining repetitive (with a range from minutes to days) and synoptic (with regional and global coverages) observations. These datasets when analyzed in assistance with GIS and supplemented with in-situ field measurements produce highly credible outputs. These could be used for a number of applications, such as evaluation of hydrological resources, crop inventory and forecasts; drought and flood damage assessment, investigation of earthquake impact zones etc.

Space Science and technology are playing an increasingly important role in varied activities such as communication, resource surveying, environmental management, global positioning, navigation, meteorology, disaster monitoring [15] etc. Pakistan being fully aware of the potential and importance of space research for sustainable development is endeavoring to develop indigenous capabilities in space science and technologies and promote their use at operational level [12]. SUPARCO has been pursuing Satellite Remote Sensing (SRS) applications for the last 35 years in Pakistan.

Remote Sensing, Geographic Information System (GIS) and GPS occupy an important position in programs of resource surveying and environmental monitoring applications in SUPARCO, PMD, PARC etc. These technologies are gradually gaining popularity within the national user organizations for use at operational level. Pakistan like other developing countries in the region is facing problems of rapid and unplanned urbanization, natural hazards, deforestation, environmental deterioration etc. [12]. GI systems are

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widely being used for developing intelligent maps which can be manipulated as desired and which are backed up by huge databases. The growing demand for environmentally sensitive management of water, air, soil, forest, agriculture, wildlife, etc., is increasingly being met by GIS technology [12].

HISTORICAL EVOLUTION OF GEO-INFORMATICS IN PAKISTAN

The first formal activity of the use of GI in Pakistan initiated by Hunting Survey in 1956, which provided systematic aerial photographic coverage of the whole country [4]. However, the first aerial surveys were carried over most parts of the country in 1936, when Pakistan was the part of undivided India [1]. The output of the Hunting Survey was in the form of geometrically corrected aerial photographs, on large to medium scales (Fig. **1**). Quite amazingly, this survey allows mapping of resolution as high as 1:20,000 scale and the aerial surveys can easily be tailored to the specific needs of the particular user. These air photos were extensively used by Survey of Pakistan and academicians in few universities of Pakistan during late 1950s and 1960s.

Early 1960s was very important period, as it witnessed 'quantitative revolution' in geography, which further established the utility of computers to address spatial problems. This was further supplemented by the 'space race' in the world, as a result of which 100s of satellites were set into the space to capture useful data of the earth's environment on a coarse spatial resolution (1-4 Km), especially metrological data. The decade of 1970s provided a solid foundation for the extraction of environmental data on relatively high resolution (80 m). This was possible because of the launching of an American satellite, viz., Earth Resource Technology Satellite (ERTS-1) which was later named as Landsat-1. This opportunity was timely utilized by SUPARCO, as the development of National Remote Sensing Centre and is known as RESACENT in 1973. The centre has been involved in acquisition and interpretation of remotely sensed data especially Lansat-1 imageries [1]. Coarse resolution Multispectral Data (MSS) of Landsat-1, 2 and 3 provided excellent assessment of associated problems both in rural and urban (Fig. **2**) areas of Pakistan. To ensure the prompt availability of remotely sensed data in Pakistan, SUPARCO has established a Ground Receiving Station (GRS) in Islamabad for the reception and pre-processing of LANDSAT (MSS and TM), SPOT and NOAA data in 1989, which was earlier proposed by Mehmud [3].

During 1980s, RESACENT's laboratories of SUPARCO were already highly equipped for interpretation of Landsat, SPOT, aerial, radar and conventional data. Apart from conducting research in important fields of agriculture, water

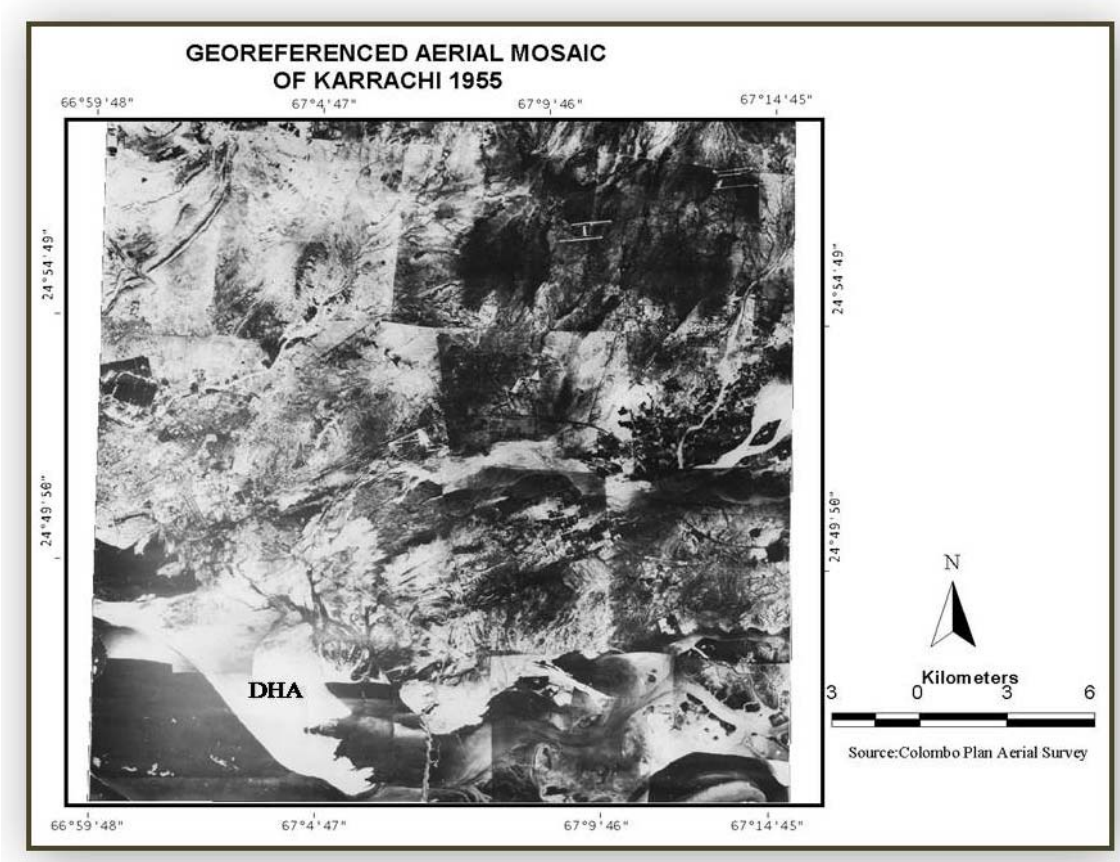

Fig. (1). Part of Karachi on Aerial Photograph Captured Under Hunting Survey [4].

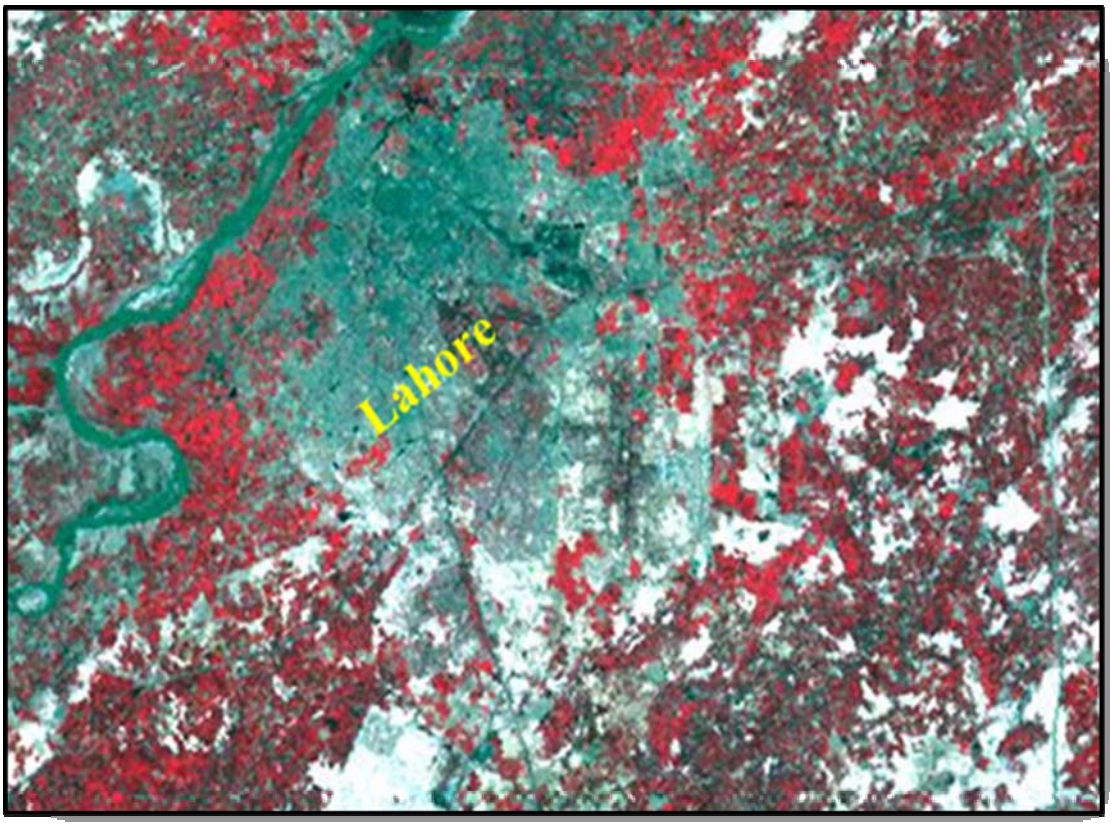

Fig. (2). A Synoptic View of Lahore (1973) through Landsat-1 on 80 m.

resources, geology, environment, land-use and urban studies, RESACENT use to provide a vital link with scientists working in other national agencies and government departments in these disciplines [1]. During 1980s, SUPARCO was the main user of SRS data beside some governmental organizations like Meteorological Department, Ministry of Environment and other organizations such as IWMI, NESPAK, IUCN and WWF Pakistan. Similarly, in Universities like Karachi, Peshawar and Punjab SRS data has been utilized significantly in the Departments of Geography, Physics, Geology and Space Science. However, SRS data at that time were highly expensive beside the foundation costs of hardware and software.

The era of 1990s proved to be highly productive and contributed scientifically in the nation building in many branches of science and technology. As reported by Qadri [10], the Government of Pakistan has invested a considerable amount of development grants and foreign aids in establishing GIS and mapping facilities in various organizations. This was also well supplemented by high resolution satellite data and the introduction of internet technology in Pakistan. A wide range of SRS data was available at very nominal cost. Consequently, it is being reflected as monitoring and evaluation tool for the resolution of many environmental, planning and management issues. For example, Kashif and Rangoonwala [6] used such data for monitoring of Riverain forest of Sindh through Lansat TM. Similarly, GI technologies has been used extensively for forest assessments since the early nineties through the Forest Sector Master Plan (FSMP) that allowed the interpretation of Satellite Imagery as an independent estimate of forest cover. The FSMP interpretation was carried out in 1990/91 using 54 Landsat Satellite Thematic Mapper images at a scale of 1:250,000 covering the whole of Pakistan [14]. Kazmi [21] used it for the evaluation of mosquito breeding grounds in Karachi (Fig. **3**). ECIL has developed base-map of Karachi with UNDP for crime analysis and for the Staff of CPLC [17].

During the current decade, i.e., 2000s, the availability of cyber medium (the internet), high resolution SRS data, user friendly GIS software and GPS ground data are the main factors contributing for the exponential growth of GI in Pakistan. The applications are quite visibly reflected in resource management, environmental monitoring, weather forecasting, city planning, crime mapping, disease ecology, vehicle tracking, navigation, cellular phone operations, etc. The acknowledgement of GI applications in various sectors are also noticeable in popular writing as well [20].

The usage of SRS data now being utilized not only by Space Scientists, Geographers, Geologists, and Engineers but equally valuable information source for Agriculturists, Botanists, Meteorologists, Hydrologists etc. For instance, Asif and Ahmed [5] have extensively used this technology for the assessment of waterlogged and saline areas. Furthermore, Malik and Husain [2] have effectively evaluated the

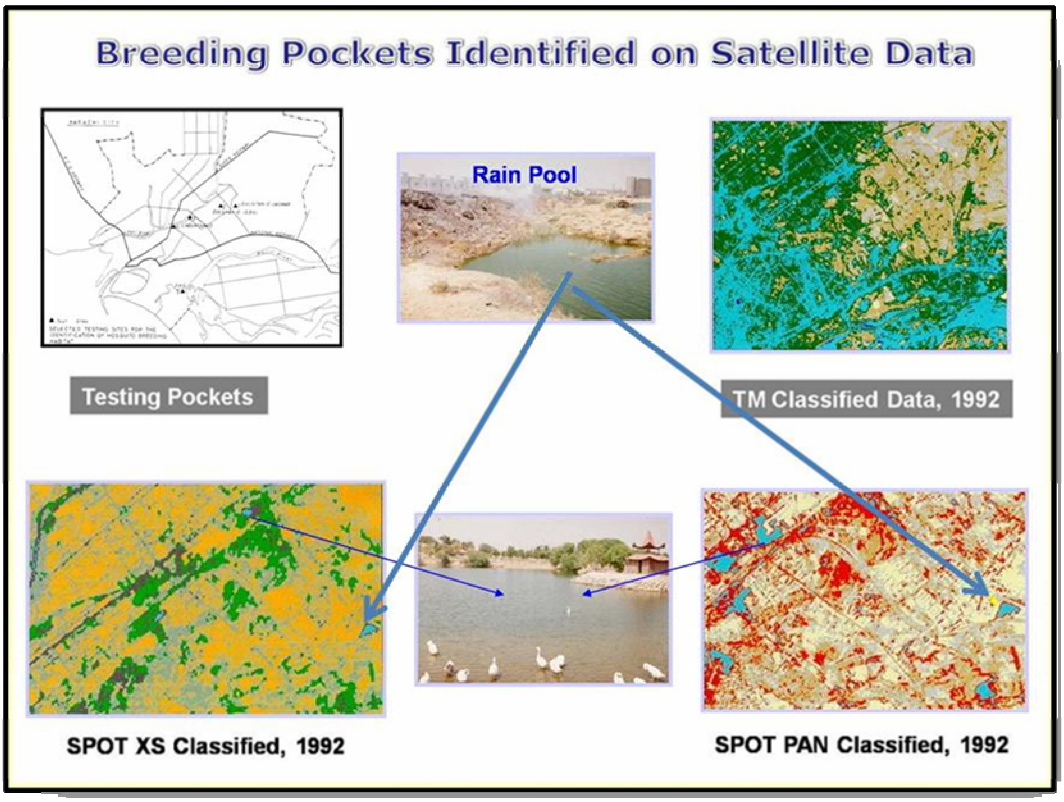

Fig. (3). Monitoring of Mosquito Habitats on SPOT and Landsat Data.

utility of SPOT data for Land cover mapping in connection with the vegetation studies. Similarly, Abdullah and Umer [11] explored the possibilities for detecting pest affects by utilizing various remote sensing techniques for spectral image acquisition including satellite imagery, airborne images from chartered or model planes and tethered balloons.

The resonance of GI technology in Pakistan was more prevalent after the earthquake of October 2005, when many national and international organizations developed up-to-date maps for the damage assessment (Fig. **4**), [7].

Another area of GI application is for Master and land use planning, ECIL, OCL, EA, Techno and AA consultants used satellite data for this purpose. Naqi and Siddiqui [9] reported that SSGC was the first organization uses GI for Natural Gas utility management in South Asia. Now many city district organizations Like CDGK, CDGH, CDGL and CDGP are Using GI for their respective spatial operations. Utilities organizations such as KW&SB, PTCL and KESC are about to establish their GIS divisions.

FUTURE OF GI IN PAKISTAN

The future, *i.e.*, the vision and direction of GI in Pakistan is quite optimistic. People are more aware of this technology through media and internet, Google-Earth in this regard is playing a vital role to disseminate the technology at layman level. The utility of GI would certainly be multiplying both in public and private sector in coming future. However, for this we need to have more developers in the field rather than the just users. Parihar [16] summarized the affectivity of GI teaching in higher education. With the advent of new tools such as SAR data processing and applications, Radar interferometry, Space borne hyper spectral data applications, Mobile GIS, Image processing and GIS modeling more applications avenues are prominently visible. The capability would be more refined in diversified applications such as Cyber cartography, LIDAR applications, 3D modeling, Auto vector generation and Web based GIS [12]. After launching of BADR series of experimental Low Earth Observational satellites (BADR-1 and BADR-B) in the 1990s and early 2000s, SUPARCO now plans to launch in near future the high resolution Pakistan Remote Sensing Satellite (PRSSS) to meet the national and international user requirements in the field of satellite imagery [18]. This would further provide low cost HRS data to the user community in Pakistan and bring more scientific innovation for Pakistani scholars. Many tracking companies are working to produce digital navigation maps which would be available in local markets shortly. Cellular phone companies like Mobilink and Telenor are about to provide GPRS services and with backdrop raster map of Karachi to their customers. Without qualms, all of this would significantly contribute for an unprecedented growth and great future of GI technology in Pakistan. This could further be boosted with the introduction of GI at school and college level, as few schools in Pakistan have already taken initiative in this regard.

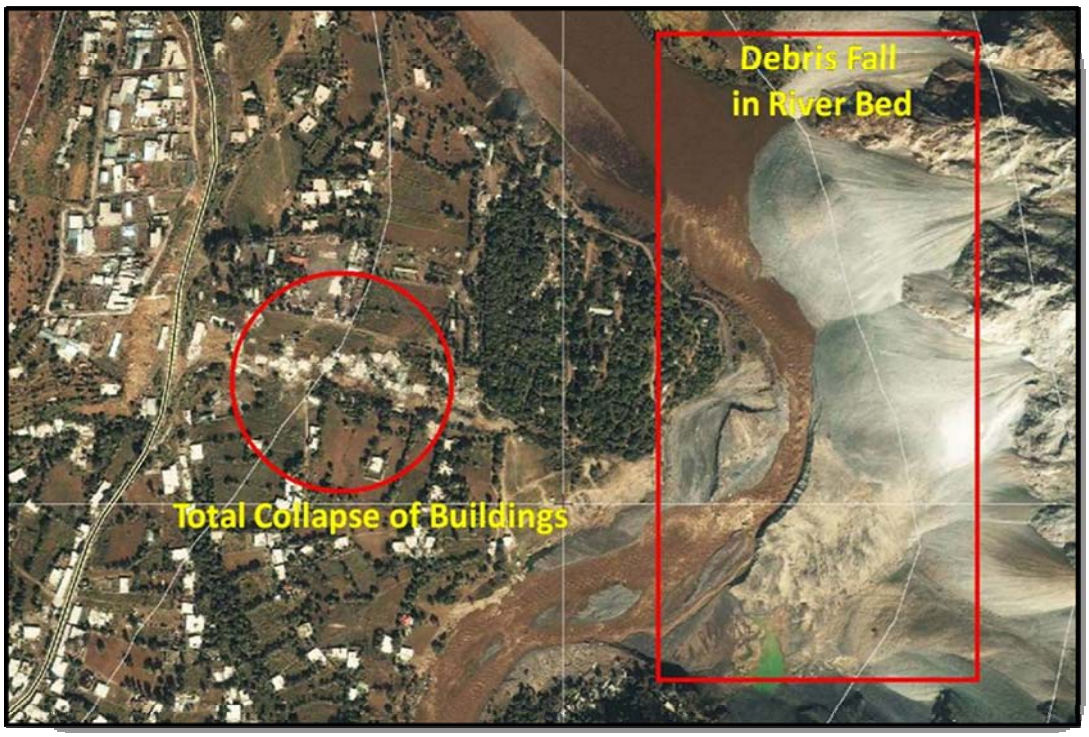

Fig. (4). Post Earthquake IKONOS Image of Jehlum River, near Muzaffarabad [13].

CONCLUSION

The review of GI technology in Pakistan reveals that this technology initially utilized minimally only by the scientific community in Public Sector (particularly by SUPARCO) and few Universities (such as Karachi University) during 1970s. This technology gradually spread out to various public and private sector organizations with the advent of new technologies like PCs, GIS and temporal availability of satellite data during 1980s. During this time, SUPARCO was the major contributor to resolve the major issues faced by Pakistan beside some NGOs like IUCN. The explosion of GI technology started in 1990s when many Public and Private organizations extensively used GI in their applications to address some of the critical issues. Recently, GI technology introduced to most of the people in Pakistan through Google-Earth and cyber media. GI technology now being used at school level and is part of the curriculum both at Higher Secondary and Secondary level. There is a dire need to integrate and network all of these isolated islands to make GI beneficial at grassroots level. Data availability and standardization in terms of web portal and warehouse is critically important to replicate its fruits to common people and scientific community.

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REFERENCES

[1] Alizai, S. A. K. and Mirza, M. I., Remote-sensing applications in Pakistan: current status and future programmes. *International Journal of Remote Sensing* , **1986**, 7(9),1147-1151

[2] Malik, R. N. and Husain, S. H., Land-cover mapping: A Remote Sensing approach. *Pakistan Journal of Botany*, **2006**, 38 (3), 559-570.

[3] Mehmud, S., Remote sensing activities in Pakistan. *Space Horizons.* **1984**. 1: 36.

[4] HUNTING SURVEY Co. LTD., *Reconnaissance geology of part of West Pakistan*. Report published for the Government of Pakistan by the Government of Canada under Colombo Plan Cooperative Project: Toronto. **1960**.

[5] Asif, S. and Ahmad, M. D., In, *Using state-of-the-art RS and GIS for monitoring water-logging and salinity* , Proceedings of international program for technology and research in irrigation and drainage, Nov. 11-12, Lahore, Pakistan. **2000**.

[6] Kashif, A. and Rangoonwala, A. In, The use of Remote Sensing data to monitor *riverain forest along the Indus River in Pakistan*. Towards Digital Earth : Proceedings of the International Symposium on Digital Earth Science Press: Beijing, China, **1999**.

[7] Kazmi, J., H., In, *On the use of Remote Sensing and GIS techniques in post-earthquake damage assessment and rehabilitation in Pakistan*, Proceedings of the "interdisciplinary workshop on management of earthquake risks". August, 28-29: ETH Zurich, Switzerland, **2006.**

[8] Naqi, S. A. and Siddiqui, Z., In, *Systematic GIS development and its successful implementation in SSGC- Pakista*, Proceeding of ESRI Users Conference: San Diego. USA, **2006.**

[9] Qadri, S. M. H., In, *A Proposal in view of the lessons learned: planning for the establishment of a long-lasting Geographic Information Systems*, Proceeding of the second Asia-Pacific conference on multilateral cooperation in space technology and application, April, 22-26, Islamabad, Pakistan. pp: 276-284. **1995**.

[10] Abdullah, A. and Umer, M. Applications of remote sensing in pest scouting: evaluating options and exploring possibilities. (Accessed February 21, 2007) www.nu.edu.pk/cair/Papers/174.pdf.

[11] Ali, J. An overview of space applications in Pakistan, www.isnet.org.pk/Downloadables/country_reports.pdf . (Accessed February 19, 2007)

[12] DLR. 2005. Mapping Pakistan earthquake. http://www.zki.dlr.de/applications/2005/pakistan/pakistan_2005_en.html (Accessed August 19, 2007)

[13] Forest Resources Development Service (FRDS), Brief on national forest inventory (NFI) of Pakistan. Food and Agriculture Organization (FAO). Rome. June 2007. www.fao.org/forestry (Accessed August 18, 2007)

[14] Jilani, R. and Haq, M., Monitoring disasters in Pakistan using satellite data, www.isnet.org.pk/Downloadables/remote_sensing_applications2.pdf. *(Accessed September 11, 2007)*

[15] Parihar, S. M., Geo-informatics in higher education. www.i4donline.net. (Accessed November 11, 2007)

[16] Pryjomko, R., ArcView GIS supports crime analysis in Karachi, Pakistan. Retrieved from http://pbosnia.kentlaw.edu/projects/warcrimes/gis/victor/articles/pakistan.html. (Accessed March 22, 2007)

[17] SUPARCO, Pakistan Remote Sensing satellites. http://www.suparco.gov.pk/pages/prss.asp. (Accessed March 22, 2007)

[18] Wikipedia. 2007. Geo-informatics. Wikipedia.com (Accessed November 5, 2007)

[19] Ahmad, M., Majeed, M. A. and Haouala, R., Monitoring Agriculture with Remote Sensing. Daily Dawn. September 10, **2007**.

[20] Kazmi, J. H., Use of Remote Sensing and GIS techniques for the forecast of malarial vector in Karachi and its environs, Unpublished post doctoral dissertation under the Fulbright Program. University of Georgia. Athens. U.S.A, **1999.**