Towards Innovative Problem Solving Methodologies for Less Developed Countries in Asia

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Abstract: In this paper we discuss the need to develop appropriate methodologies for geo-information production, management and dissemination from remotely-sensed images and *in-situ* geospatial data in less developed countries (LDCs) primarily in Asia. While in general the same methods are applicable for both developed and LDCs, certain environmental, cultural and socio-economic factors frequently render some methods more appropriate and workable in different areas. In consideration of the above, the International Society for Photogrammetry and Remote Sensing (ISPRS) has set up a working group (WG) to address this theme until 2008. Some of the factors that have led to the establishment of this working group are: (i) image acquisition, especially space-borne, has traditionally been unaffordable for many countries; (ii) the recent successful, and forthcoming launch of "affordable" micro-satellites in Africa and Asia, respectively, as part of the Disaster Management Constellation (DMC), has increased the interest of governments and scientists in LDCs in remote sensing (RS), hence there is a need to develop appropriate tools to process the data acquired; (iii) ICT infrastructure constraints limit data access, transfer and analysis capabilities.

Consequently, the principal WG's terms of reference are the following: (i) convert theoretical methodologies and models into practical operational ones suitable for LDCs; (ii) develop integrated methods for remote sensing and *in-situ* data collection for data-sparse regions; (iii) develop appropriate image processing methods using simple computer technology; (iv) develop algorithms for improvement and calibration of airborne videography for geometrically less significant applications and thematic map updating in LDCs; (v) carry out a structured assessment of existing bottlenecks (besides cost for imagery and hard- and software), that prevent effective transfer of existing methodologies; and (vi) evaluate open-source or low-cost remote sensing and GIS software tools (e.g. OSSIM, ILWIS) to address the actual needs of LDCs.
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1. Introduction

Spatial data are playing an increasingly important role in the national development of any country, supporting issues as diverse as natural resource mapping and exploitation, infrastructure planning and monitoring, disaster risk reduction, and enforcement of national security and sovereignty concerns, among others. Furthermore, it has been noted that if the UN's Millennium Development Goals, in particular halving poverty by 2015, are to be achieved, extensive amounts of spatial data are needed. Corresponding developments, mostly technical, have been evident for years and are accelerating, albeit at vastly variable rates. While the developing world has long invested in Earth observation (EO) technology, and more recently in Spatial Data Infrastructure (SDI), the gap over progress in less developed countries (LDCs) is generally widening[1]. This is in spite of (i) increased awareness of the benefits of spatial data, (ii) greater affordability of acquisition, processing and dissemination means, and (iii) an improved collaboration with and capacity building in LDCs. A more interesting recent development relates to advances made by some nations that had not previously been very active in the Geoinformatics arena: within the last 3 years, Nigeria, Algeria and Turkey have joint the previously rather exclusive club of space-nations, having acquired their own satellites as part of the Disaster Management Constellation (DMC), and Vietnam, Thailand and China are to follow

[1] The distinction between less developed and "Western" countries used here is a greatly simplified view, and may be misleading. It is used here to contrast countries that have heavily invested in Geoinformatics, including in Earth Observation and spatial data infrastructures, and whose authorities at all or most levels of government make substantial use of those data, and those countries where little adoption of such technologies has taken place, mainly for lack of financial resources. It has to be acknowledged, though, that also some nations with low GDP have founds means to implement Geoinformatics tools and methods.

soon. This suggests that even countries with limited financial means can implement advanced geodata acquisition tools, given some political commitment.

The variability in adoption of existing technologies, and development of indigenous capacity, is also raising questions about the optimal ways to steer developments in the Geoinformatics field. There are clearly obstacles that prevent a wide-spread implementation of existing technologies and methods, financial limitations only being the most obvious ones. There are also pertinent socio-economic, cultural and political factors that reduce or limit the use some existing solutions, in particular in LDCs. This is the reason the International Society for Photogrammetry and Remote Sensing (ISPRS) in 2004 established a new working group (WG) to address this issue until the next Congress in 2008. The WG, entitled "Innovative problem solving methodologies for less developed countries" falls under Technical Commission VII.

The aims of this paper are to (i) introduce the objectives of the WG, (ii) review them in the Asian context, and (iii) generate interest in and support for the research activities of the group.

2. A need for a special Working Group

For nearly 100 years ISPRS has fostered research and development in remote sensing and photogrammetry, and advances mainly made in more developed Western countries have also found adaptation in the rest of the world, sometimes gradually, at other times through leapfrogging. However, obstacles and challenges remain, and prevent a more widespread implementation of what in more developed countries are largely considered off-the-shelf technologies.

- The costs still associated with many RS image sets and processing means is frequently considered prohibitive, at least in comparison with the perceived use of such data.
- Many standard methods (e.g. in landcover change detection) rely on the availability of archived Geoinformation and accurate and current base data, which frequently do not exist in LDCs.
- Facilitated web-based access to RS and other spatial data, welcomed in the West, remains frequently off-limit in LDCs due to continuous bandwidth limitations. Here in particular, though, the contrast in development between different countries is immense. In particular in Africa, wide-spread internet-access remains a distant hope, while in many Asian countries broadband access is becoming the standard.
- Underdeveloped ICT infrastructure, coupled with the persistent use of low-end computer systems, in terms of RAM, speed and storage, hinders efficient geodata download, processing, storage and transfer, even with proven methodologies.
- This last point also limits the use of modern, typically computationally demanding RS/GIS software on which the majority of new methods is developed. The high cost of proprietary software programs further limits their implementation.
- Insufficient capacity (institutional, organizational and human) in geo-information production, management, dissemination and use.

In addition to those, however, also recent successes have informed the establishment of WGVII/7, e.g.:

- The successful launch of Turkey's Bilsat-1, Nigeria's NigeriaSat-1 and Algeria's Alsat-1, all relatively inexpensive micro satellites with 32m resolution that form part of the Disaster Monitoring Constellation (DMC). This has raised wider interest also of other governments of LDCs in the use of remote sensing for mapping of resources. In the next 2 years, China, Vietnam and Thailand will also receive DMC satellites, while also other Asian countries (Malaysia and Singapore) will launch their first EO satellites soon (see below).

The purposes of the working group are thus manifold. It was set up to foster research into the optimal way to transfer methods originating in the developed world to LCDs, to address regional environmental, historical, cultural and political reasons that may hinder implementation of proven methods, and to work towards overcoming the technical hurdles listed above. The following section briefly outlines how the WG fits into the hierarchy of Technical Commission VII, and its Terms of Reference (TORs).

3. ISPRS Technical Commission VII: Thematic Processing, Modeling and Analysis of Remotely Sensed Data

Within ISPRS's structure a total of 8 technical commissions (TCs) has been established, each with a variety of working groups to address individual sub-themes. TCVII has 7 working groups, in addition to an inter-commission

WG (see http://www.commission7.isprs.org/ and http://www.itc.nl/isprsc7/wg7/). The aims of the commission are to foster and organise research activities in the following areas:

- Relationship between spectral, radiometric and temporal properties of objects and surfaces, their physical and chemical properties and their variations.
- Image classification and analysis methodologies.
- Analysis of characteristics of multi-spectral, hyperspectral, multi-sensor, microwave and multi-temporal image data for extraction of attribute information.
- Methodologies of computer-assisted interpretation and analysis of remotely sensed data.
- Validation of data and information using laboratory and in-situ methodologies.
- Improving atmospheric modeling for radiometric correction.
- Multi-source data fusion and integration techniques.
- Modeling of satellite data derived parameters.
- Global databases and determination of indicators of change for global modeling, monitoring and sustainable development.
- Integration of remote sensing and GIS techniques.
- Aerosol and particulate detection and identification.

Given the breadth of technical issues, though primarily revolving around remote sensing, the following working groups were established, of which this paper focuses on WG VII/7:

WG VII/1: Fundamental physics and modelling
WG VII/2: Information extraction from SAR data
WG VII/3: Information extraction from hyperspectral data
WG VII/4: Advanced classification techniques
WG VII/5: Processing of multi temporal data and change detection
WG VII/6: Remote sensing data fusion
WG VII/7: Innovative problem solving methodologies for Less Developed Countries
Inter Commission IV/VII WG: Derivation of global data, environmental change and sustainability indicators

4. Aims of WG VII/7

For an initial period of 4 years, until the next ISPRS Congress in 2008, WGVII/7 is tasked with (i) steering the adaptation of existing methods and approaches for developing countries, and (ii) foster the development of solutions uniquely suited to the given regional/national requirements. Hence the focus is on the following issues:

- Convert theoretical methodologies and models into practical operational ones suitable for LDCs.
- Develop integrated methods for remote sensing and *in-situ* data collection for data-sparse regions.
- Develop appropriate image processing methods using simple computer technology.
- Develop appropriate methodologies for multi-source, multi-resolution (temporal, radiometric) and spatial data fusion for new mapping and map updating in LDCs.
- Assess the relevance of remote sensing methods developed by other working groups to LDCs.
- Liaise closely with TCVI WG on Transfer and Technology, with other TC's on methodology development, and with regional ISPRS members such as SELPER, AARSE, EARSeL and AARS.

In addition to these official TORs of the working group, several issues are receiving particular attention:

- Development of algorithms for improvement and calibration of airborne videography for geometrically less significant applications, for thematic map updating in LDCs. Substantial progress has already been made in the use of non-calibrated image sequences, including vertical, oblique and transverse video data [e.g. 1, 2], with results indicating that information of sufficient quality can be derived for detailed urban mapping, but also for small-scale cartographic purposes and natural hazard applications [3].
- Structured assessment of existing bottlenecks (besides cost for imagery and hard-and software), that prevent effective transfer of existing methodologies. As mentioned before, in particular data cost and insufficient soft-and hardware capabilities limit the widespread adaptation and implementation of existing methodologies. Hence more concerted work is needed to (i) assess the suitability of free or low-cost RS data as a viable alternative to more widely used commercial imagery, (ii) develop procedures that maximize valuable information extraction using older generation hard- and software.

- Evaluation of the utility of open-source or low-cost remote sensing and GIS software tools (e.g. OSSIM, ILWIS) to address the actual needs of LDCs, and to what extent capacity to use those tools exists or can be effectively developed.
- Development of better access possibilities to existing low-cost global and regional satellite-based data acquisition and provision infrastructure (e.g. MODIS, GOES, MSG), with focus on data reception, management and distribution.

Given the special nature of the WG, there is a deviation from the standard structure if ISPRS WGs. In addition to chair and co-chair, WG7 has 4 regional coordinators that provide a direct input on specific regional Geoinformatics requirements and unique aspects, and help to steer corresponding WG activities.

5. Relevant developments in the Asian region

1) Space-infrastructure developments

Next to the traditional EO-satellite operators (EU, US, Canada and Japan), a second centre of development has evolved in Asia, where about half of the satellites currently planned or under construction will be operated. Progress has primarily been driven by Japan, India and China. In particular India, under pressure to use available funds for more immediate and tangible development efforts, has opted to invest heavily in EO-infrastructure and related capacity building. Its IRS-satellite range now ranks among the most comprehensive in the world, and data are widely used in the country. Similarly, China is now pursuing an aggressive EO-development strategy. It is particularly benefiting from the recent availability of low-cost yet versatile satellite infrastructure, either designed as micro-devices (<100 kg), or specifically assembled from off-the-shelf technology. One example of micro-satellites is China's component of the Disaster Management Constellation (DMC), named DMC+4 or Tsinghua-1, to be launched in late 2005. In addition, a constellation of 5 low-cost radar satellites, the Surveyor SAR, is being built, with launch scheduled for 2007.

While the resources of these larger nations may eclipse those of smaller countries in the region, there is nevertheless a strong investment in space technology elsewhere as well. In 2003, Turkey's component of the DMC, BilSat1, was launched, and in 2006 Thailand and Vietnam are expecting the launch of their DMC members, ThaiPaht2 and VinSat1, respectively, bringing the whole DMC constellation to 7 members. Malaysia, too, will launch a high-resolution (5m pan) satellite, RazakSat, in early 2006, and a year later Singapore's X-Sat (10 m multispectral) is expected to become operational. Including also Korea (Kompsat), Taiwan (RocSat) and Japan (JERS, ALOS and others), a total of 10 Asian countries are about to have access to their own EO technology. In some respects some of the new Asian space technology has technical advantages over Western systems. For example, ALOS and India's CartoSat-1 have stereo-imaging capabilities, bringing the potential of high-resolution space-borne digital elevation models (DEMS) to the non-commercial domain. Cheaper technology is also fuelling the development of niche-systems. While traditional systems fell more in the one-fits-all category, with all inherent compromises, there is an increased trend to operate purpose-driven space infrastructure, such as the DMC. With that have also come new means of cost sharing, away from sole single-governmental/ space-agency or commercial funding. The DMC is jointly owned by 7 countries, where each has ultimate control over their own satellite. This, though, also leads to a risk of limited data sharing [4].

From our WG's perspective these developments indicate the availability of vast data amounts of different data/image types, for many of which the need remains to develop or adapt methodologies to derive useful information, yet also more diverse challenges. There is a large capacity for synergy, as distinct but complementary data types could be shared and used together. However, improved data availability mechanisms are also required. There is currently no image-distribution system for Kompsat (Korea) data or imagery from the TES satellite (India), and distribution of data from RocSat (Taiwan), to be done by SPOT, has also been delayed [5]. Lessons can also be learnt from the traditional EO-nations. While many data products from US-operated systems (e.g. TERRA and AQUA) are easily, comprehensibly and cheaply available – and are thus widely *used* – imagery from ENVISAT and other either expensive or rather inaccessible systems lead more of a niche existence.

Challenges to be addressed here not only include technical compatibility problems, but also wider cultural and linguistic hurdles typical for Asia. While Latin America is characterized by a certain amount of homogeneity, and Africa is, generally speaking, divided only into anglo- and francophone countries, Asia's diversity is far more extensive, creating communication and information exchange challenges not seen in other parts of the world. Furthermore, space capacity developments and data availability policies are marked by the socio-economic philosophy followed by the country in question (e.g. socialist vs capitalist), and to a good extent also by the power of the military. Spatial data are frequently regarded as an element of national security and are thus in many cases kept inaccessible, a problem growing with increased availability of high-resolution optical data, and also to be addressed by the working group.

2) SDI for Asia

Although the focus of the WG is on remote sensing, integration of image data with GIS and spatial data infrastructure is one of the focal points. This is a natural requirement given the growing need to develop full data and information processing, dissemination and management systems. Even though there has been increased cooperation within the region (e.g. through ASEAN, or the Economic Cooperation Organisation (ECO – the equivalent more centred around Central Asia), spatial data are still acquired and organised according to individual national standards, resulting in variable availability and data standards, and limited exchange. Even some intergovernmental efforts, such as the UN supported Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP)' pilot-study projects, were hampered by the unwillingness of some countries to make datasets available [6]. Nevertheless, the development of an Asia-Pacific Spatial Data Infrastructure (APSDI) is continuing, and is expected to lead to a network of regionally distributed, rather than centralised databases. Those persistent efforts have led to some success, such as the establishment of a regional geodesy network, including a defined datum, a prerequisite for integration of multi-national spatial data. However, PCGIAP continues to encounter limited support, resulting from (i) lack of appreciation of the benefits of a regional SDI, (ii) inconsistency of the SDI's conceptual framework with expectations and (perceived) needs of the member countries, and (iii) limited understanding of the intricate interactions between social, political and economical aspects [6].

3) Software and human capacity

Both data management (including processing, storage and dissemination) and capacity building in western countries are increasingly technology-driven, to a point that a transfer to LDCs is hindered. The work of the International Institute for Geoinformation Science and Earth Observation (ITC) in international capacity building has frequently had to confront this problem. Either required software or hardware tools are not available, the necessary base data are nonexistent, or the required more large-scale human capacity (including system administration and inter-agency collaboration) are lacking. With regards to technological hurdles, the growing prominence of open-source tools is encouraging. Free- or shareware GIS or RS programs, such as GRASS, OSSIM or ILWIS, are available, comprehensive in scope, and there to use (nearly) free of charge (see www.opensource.org or www.gnu.org). For a more comprehensive evaluation see [7]. Coupled with free or low-cost spatial data, such as at those from ASTER, MODIS or MSG, or slightly older Landsat data from the Global Landcover Facility, many standard processing steps can be carried out.

The human development aspect, naturally, requires a more long-term effort. The most encouraging indication of successful efforts is the move from training in Western countries to in-region education. In Asia this is occurring though collaborative efforts, such as joint programs by ITC with IIRS in India, Wuhan University in China, or the upcoming ITC-UNESCO Laboratory for Geoinformation Processing in Mongolia.

6. A call for action

There are numerous examples of how Geoinformatics has found a way into daily operations in many Asian countries. However, the challenges noted in this paper also remain a reality, and a reminder of what remains to be done. The issues to be addressed within the framework of the WG are clearly spelt out. We would like to encourage the members of the Geoinformatics community to take up the challenge and contribute, be it with new methodologies, adaptations of existing tools, case studies, etc. There will be opportunities to present those results, for example in special sessions of the WG during the Midterm Symposium of TC VII in May 2006 in Enschede, the Netherlands (see http://www.itc.nl/isprsc7/symposium2006/), at the XIIth SELPER Symposium in Cartagena, Columbia in 2006, or the 6th AARSE conference in Cairo in October 2006. Furthermore, membership in WG 7 is open to all interested members of the Geoinformatics community. All relevant information can be found at http://www.itc.nl/isprsc7/wg7/.

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