Innovative use of Remote Sensing Images for Pro Poor Land Management

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Key words: Pro Poor Land Management, Remote Sensing, Photogrammetry, Geo-Information Technology, Innovative Tools, local Land Information Systems

SUMMARY

According to Homeless International (2005), there are about 900 million people who live in slums worldwide, and among them are 570 millions that live in the Asia-Pacific region. They do not have safe and secure housing. They are mostly evicted from their lands, and compelled to live in health- and life- threatening environments. Millions of people live on marginal land, vulnerable to flooding, landslides and other environmental hazards. For this purpose UN-HABITAT (2004) has launched pro poor land management concept with flexible approach depending on local society and circumstances.

This paper firstly discusses how pro poor land management approach would help the poor including women, children and disabled people to defend their rights on land. Needs and innovations that can help slum dwellers or informal settlers are discussed. Innovations are described and they are related to the three main issues namely new paradigm on land tenure concepts that allow them to gain their land rights, application of Geo-Information Technologies in the processes of land administration i.e. determination, recording and dissemination of land information on tenure and use rights of land (UN-ECE, 19996), and local land information systems enabling easy access to land information. These issues are thoroughly discussed in this paper. Then the uses of remote sensing images are then demonstrated with practical cases applicable to pro poor land management procedures.

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1. INTRODUCTION

According to Homeless International (2005), there are about 900 million people who live in slums worldwide, and among them are 570 millions that live in the Asia-Pacific region. That means that Asia contains most of the world's urban population living in slums and squatter settlements. They do not have safe and secure housing, and are largely excluded from achieving their political, social, and economic rights. Asia's slum dwellers are compelled to live in health- and life- threatening environments. In South Asia alone more than 150 million slum dwellers do not have secure tenure, leaving them open to the threat of eviction. Millions of people live on marginal land, vulnerable to flooding, landslides and other environmental hazards. Urban poverty is often underestimated, unrecognized and poorly understood.

With the background of the above situation, this paper firstly presents overview of pro poor land management concept and discusses needs and innovations that can help slum dwellers or informal settlers. Innovations relate to three main issues namely new paradigm on land tenure concepts according to their norms and values to be incorporated into urban land policy, Geo-information technologies including remote sensing (RS) and geographic information systems (GIS) in the processes of land administration (determination, recording and dissemination of land information on tenure and use rights of land), and local land information systems enabling easy access to land information. These issues are thoroughly discussed in this paper. Then the uses of remote sensing images are demonstrated with practical cases, and finally applicability of these images is then discussed for pro poor land management.

2. PRO-POOR LAND MANAGEMENT

UN-HABITAT (2004) indicates that the local authorities mostly consider slums or informal settlements as illegal. When the slum dwellers arrive in the cities, they usually get land or house through informal processes or family members and used whatever materials they could find to erect a house to live in. They are invisible to the city authority because they never followed any formal/legal processes to live in the city. Moreover they are not formally employed and many of them suffered from invisibility are children and women. Therefore cities do not plan these areas, and the maps or layouts showing streets and sites are not available. People do not have officially recognized street addresses. Consequently they do not receive the services such as shelter, water, roads, sanitation, and sewerage.

To help these people, the city authorities need to plan these areas and provide land which is reasonably close to income opportunities and basic amenities in order to make it a real alternative to squatting. According to UN-HABITAT (2004), there are several problems on access to land, ranging from visibility of the poor, the tenure security to sophisticated sites-and-services programs and land readjustment schemes. Some of the problems that relates to the pro poor land management system are given below:

- Centralized decision making: In many situations, national government takes all the authority, functions and programs around land management. Local authorities hardly play a role.
- Insufficient use of urban space: Urban space means land in and around city and these land need to organized, plan and used in an efficient way providing land for services and housing.
- Public sector dominated approaches: These approaches exclude important stakeholders and civil society such as private sector land developers, NGOs helping slum dwellers, etc. in decision making for the procedures and standards.
- Rigid and costly regulatory frameworks: strict and inflexible laws to be followed in the procedures and standards.
- Poor land recording systems and centralized information systems: Title or Deed registration systems are usually inefficient and very costly systems. Record systems are poorly maintained and not complete. There are also inefficient methods of collection, maintenance, storage and dissemination of urban land information in such centralized systems.

The above situations lead to a long delays or if not impossible in delivery of a good land management program to improve the economic, social and environmental conditions of the slums and dwellers in cities of the developing countries.

In actual fact, local authorities wishing to remedy the housing conditions of the urban poor are left with only two major - more or less costly - options to provide more land: (a) legalizing the tenure of illegal settlers where they are and allowing them to pay below market prices for the land; and (b) allocating public land to low-income households at subsidized rates. These options proved to be ineffective and not sustainable in the longer term.

2.1 Needs and Innovations

In order to bring slums/informal settlement in the cities into the formal systems, among others, one of the possible ways in low cost and sustainable manner is to use the “pro poor land management system” in slum upgrading process. Its main characteristics are: a) making the poor visible, legal citizen of the city enabling participation in the decision making; b) enabling the settlements where they live to be included in the planning; c) developing procedure for tenure security and providing services that the poor can find accessible and affordable; and d) allowing local land information systems transparent and close to the poor and civil society who require the information for making decisions on their land (UN-HABITAT, 2004).

The approach in pro poor land management system would normally include informal processes which can be considered as an asset for the formal system. Such informal process has always community participation which, consequently, induces social obligations on the use of land. Land management responsibility is decentralized to the local authorities, and this includes land administration activities (recording, processing, storing and disseminating land information). This allows rapid dispute resolution making more empowering the poor, accountability and transparent processes. The plan so developed would be integrated into the city’s development plan. One of the challenges that local authorities would face is

regularizing tenure security in order to meet needs of the poor. The poor would be capable of improving their land and housing conditions by themselves if they are provided some type of security, or at least perceived security, of tenure. The following are the basic needs for a pro poor land management (UN-HABITAT, 2004):

- development of appropriate and flexible tenure form
- participatory planning approach for informal land delivery processes
- linking to service to communities' capacity for sustainability
- a decentralized land administration that uses local capital, partners with local authorities
- cost recovery approach or self reliance

From the view point of land administration for regularizing slums or informal areas, three innovations can now be seen as follows (Tuladhar, 2005b):

- New paradigm on land tenure concepts according to their norms and values to be incorporated into urban land policy;
- Appropriate use of Geo-information technologies (GIT) including remote sensing (RS) and geographic information systems (GIS) in the processes of land administration (determination, recording and dissemination of land information on tenure and use rights of land); and
- Local land information systems enabling easy access to land information

2.2 New Paradigm on Land Tenure Concepts

North (1990) defines institutions as 'the rules of the game in a society or more formally, are the humanly devised constraints that shape human interaction'. Institutions are, therefore, any forms of constraints that human beings devise to shape human interaction, and organisations are the players of the games that provide a structure to human interaction. In this sense, land tenure (or property right) is regarded as the institutionalized relationship of people involved in the use of land and distribution of its products (Lunning, 1995). Institutional arrangements for legitimizing land tenure include laws and regulations. The normative behavioural code refers to the cultural values that legitimize arrangements and constrain behaviour. This arrangement are always different from one country to another and even within one country, as it is often influenced by history, politics, culture, religious and social systems and economic situation. The relationship between an individual or a group of people or communities and a spatial unit of land through tenure rights is the most important part of land tenure and its administration (Tuladhar, 2004). According to the norms and values in a particular society (or in a country), we can distinguish into three kinds of tenure systems can be distinguished:

- Statutory tenure/laws. These are described as the right to, and the use of, the land supported by law (case law or statute law). In many countries, the historical source of law is custom, and thus the written law replaces custom. In western countries, the written law came about as a result of the Napoleonic code based on the concepts of liberty, equality and fraternity (Platteau, 1996). In many developing countries, the written law was influenced by colonial administration. Statutory land tenure is thus

characterized by freehold and leasehold systems. However, several countries (eg. Nepal, Bhutan) in Asia not influenced by colonization have also evolved into a statutory system according to their needs including history, culture, society, norms and values (Tuladhar, 2004).

- Customary tenure. Customary land tenure, in principle, is the mode of holding rights in land that exists through customs and traditions without written laws. These unwritten laws are often based on the experiences of the elders, and are aimed at defending the interests of the group/tribe. Since the community itself controls and keeps alive the sense of responsibility to society and to land as the common heritage to be preserved for future generations, it creates harmony and security in such society and allows any member of community access to some land within the community. In term of land use, the system ensures that all land within the community is used and unused land can be reassigned (Tuladhar, 2004).

- Informal tenure system. This is typical situation in slums or per-urban areas where slum dwellers acquire land without formal procedures. In per-urban areas (for example in Accra city, Ghana), there are constant struggles between statutory and customary tenure systems making access to land difficult through either systems (Arki-Adjei, 2001). UN-HABITAT (2004) provides a simple definition of tenure as ”the fact that other people believe the land you occupy and use is the land that you are allowed to live on and use”. That means that secure tenure comes from aspects (perception and beliefs of neighbours and local authorities) and instruments other than formal laws.

Since individual land titling programs are not able to deliver land in slums and informal settlement areas, pro poor land manage recommends an incremental approach of continuum rights (ranging from perceived or de facto tenure, customary, occupancy, anti eviction, adverse possession, group rights, lease and finally freehold) (Augustine, 2005).

Implementation of these tenure rights is different from one country to another, and one of the examples for flexible tenure can be cited in Namibia. The concept was born out of efforts to provide secure rights to families in the urban informal settlements of Namibia. There are three levels of title: *Starter Title* is both individual and group based. Second level is *Landhold title* that has all-important aspects of tenure, and the settler has the right to occupy a defined site in perpetuity. A holder of a landhold title can sell, transfer, and mortgage his/her rights over the defined piece of land. Three level is *Freehold title* that implies individual right which is capable of being sold, donated or inherited. The freehold title offers the owner the right to occupy a defined site in perpetuity (MLRR, 1995 & 1999).

2.3 Geo-Information Technologies

Recently traditional surveying concept has taken up into new shape from discipline oriented technologies, such as geodesy, surveying, photogrammetry and cartography into a methodology oriented integrated discipline of geo-information. Such methodologies are based on global positioning system (GPS), remote sensing, digital photography for spatial data acquisition, and Internet, GIS, and database technologies for data modelling, manipulation and storage and data output. They are usually combined depending on

efficiency, effectiveness and cost of techniques to provide reliable spatial information required for sustainable development (Tuladhar, 2005b).

With regards to spatial data acquisition, there are two broad surveying techniques – field survey and remote sensing (or photogrammetry). Traditional approach to land surveying is through the use of simple measuring tape and recording the measurements in the form of sketch maps or in a notebook electronically. The use of total stations or GPS is alternative technique which is highly efficient and accurate for the surveying the land parcel boundaries.

Plain table survey with alidade is an oldest technique and still practiced in some countries. But its use is rather constrained by quality of the outputs, as it depends on the field experience of individual surveyor. Output maps are then digitized and stored in a GIS database.

Alternative is to use photogrammetric (or remote sensing) technique using the aerial photographs or high resolution satellite images in which most measurements can be done in the office. The concept of stereo-model from two stereo pair aerial photographs is used to extract spatial information in three dimensions. With the advent of high resolution satellite systems in stereo, the theory of photogrammetry is of increasing importance merging the remote sensing approach. Software such as ERDAS imagine offers both capabilities of advanced remote sensing image processing and photogrammetric processing techniques. Both sets of these techniques are capable to produce the necessary standards for most land administration purposes. The result of the restitution is then a direct input into geographic information systems in vector or in raster form.

In a large new area where surveying and mapping need to be carried out, photogrammetric or remote sensing may offer a relatively rapid, cost effective, mass operation to achieve initial registration. One advantage of using images (either aerial photographs or high resolution RS images) is that they provide a historical record of the areas that can be revisited in the future to see what changes have taken place. Thus where conflicts occur in boundaries, old images can provide valuable evidence (Dale and McLaughlin, 1999). More discussion on the use of remote sensing image is given in the following section 3.

The recent development in modeling language such as unified modeling language (UML) has enabled us to design customer-oriented systems which are appropriated to local situations. Models (both for data and processes) of the system developed using such modeling language are proved to be very much flexible and iterative in order to accommodate any changes needed in the future. On the basis of geographic standards from ISO and OGC (OpenGIS), system models are developed and they form the basis for transparency and meaningful communication between different parts of the systems. Internet GIS with XML/GML capability allow users in order to share data minimize interoperatability problems among the different organisations.

2.4 Local Land Information Systems

One of the important considerations in implementing a Land Information System (LIS) is that it must be located in such a way that the poor has easy access to all kinds of services and

information delivery required for land management. Local LIS normally contains local databases (or registers) in digital form that relates to spatial and non-spatial (or descriptive) components (Tuladhar, 2005a). In order to find the contents of databases, the users/stakeholders are consulted and analyzed in term of service required and financial availability. In starting phase, system may be simple with minimum services and data, and later on it is upgraded in stepwise approach.

As an example, spatial component may contain the following information:

- Spatial units of outer boundaries – tenure units, customary areas, family parcels, individual parcel which could be represented by geometry (either graphical polygons or points including topology);
- These spatial units must have unique identifiers in a standard form;
- Locations of spatial units are always referred to national geodetic reference system

Similarly non-spatial (Descriptive) component may contain the following information:

- Links to spatial unit through unique identifier
- Register of tenure rights and right holders – chief/head of the group/village, family head, individuals
- Agreement/evidences on how tenure rights are brought to right holders

As already said, the local LIS consists of series of services (or work processes) serving the poor. These work processes may be as local adjudication, surveying, land transactions, assisting completion of tenure application forms and supplying relevant data in hard and soft -copy. Depending upon the policy of country, some services could also be privatised. Many services may be carried out by tools supported by GI Tools.

It is utmost important that the local LIS is continuously maintained. That means that the local systems are tied to central LIS system for continuous flow of information. This approach provides legality of data maintained at the local level, and local databases would be more transparent, affordable and accountable.

Discussion in the section 2.2 suggests us that there are three possible ways of defining spatial units of land in urban space according to norms and values of society in a country. First option of course is divide urban space into individual parcels which are separately owned by individual persons through statutory registration system. In case customary tenure, it may be enough just to indicate outer boundaries without going into individual parcels and in slums or informal settlement areas, it may even be graphical point forms so that it tells people live there to protect from eviction (van der Molen and Lemmen, 2005).

3. REMOTE SENSING IMAGES FOR PRO POOR LAND MANAGEMENT

As explained briefly in section 2.3, the use of photogrammetric (or remote sensing) technique is very cost effective in mass productions in comparison with field survey techniques. Because of advancement scanning technology, digital cameras, and the high resolution

satellite systems in stereo, processing of digital images has became rather rapid and reliable to extract geo-information relevant to the application fields.

As an example for the purpose of navigation, one can easily use Google Earth that was launched recently (figure 1). Such web application provides rapid visualization of the situations about the area of interests. This application supports not static display of images but dynamic in 3D environment if 3D data is available.

Figure 1: A part of Bombay Slums from Google Earth

In this respect, there is a great opportunities now offered by technological development. But we need innovations that can purposely use these digital images for pro poor land management.

3.1 Remote Sensing Images and their applications

Aerial photographs or images are a very good source for acquiring large scale geo-information. In the past photogrammetry techniques (e.g. aerial triangulation, stereo-orientations, photo-interpretation, stereo-digitizing on stereo- model) are commonly used to produce geo-information. These techniques require analogue or analytical photogrammetric plotters, and the quality is very high and comparable to the field survey techniques. Now a day, these equipments are difficult to maintain. They are now replaced by digital computer with appropriate software capable to display, orient models, process and capture information in stereo-models. But, for these automatic processes, we need to scan aerial photographs at reasonable pixel size using scanner. One can use either diapositives or original negatives of the photographs. The software not only allows carrying out tasks digitally but also allows us to produce digital elevation model of areas and orthoimages digitally. In this way, timely production is possible for a project work at the reasonable cost and quality.

Figure 2: Colour aerial photograph, a part of Enschede, the Netherlands

The figure 2 shows portion of a vertical colour aerial photograph in south part of Enschede city, the Netherlands. It also shows that it has very high interpretability for extracting physical boundaries.

However, in the use of these aerial photographs (or scanned aerial photographs), the choice of scale of photographs is quite important as it influences very much on financial aspect of the project.

If aerial photographs are taken at the scale of 1:6 500, they provide a resolution and a positional restitution accuracy of 6.5 cm. After scanning it at

15 µm it is good for the generation of 10 cm ground pixel orthophoto. Total cost to produce orthophoto covering 250km^2 can be estimated to be $92000 or 368$/km^2. If the scale of aerial photographs is 1: 13,000, a 20 cm ground pixel orthophoto may be generated. The cost orthophoto production for the same area will then be around 6420 $ or 26 $/km² (Konency, 2002).

With the advancement of CCD-chip technology, there are now very good digital cameras available in the market. There are two types of digital camera: the three line cameras and the multi-frame cameras. The three-line cameras use the well-known push broom technology with forward, nadir and backward looking views. The multi-frame cameras use multi-frame CCD sensors which can produce large digital images of up to 8000 by 14000 pixels. The advantages of such images are that radiometric resolutions are much better than film camera (Vosselman, 2005).

Another alternative is to use small format aerial photographs (SFAP) taken by a hand-held camera from aircraft. The photographs are then scanned and processed digitally. This is cheapest way to acquire photographs for small areas for rapid mapping at low cost and proved to be quite acceptable for many urban applications.

Figure 3: Rectified photographs

The figure 3 shows example of such rectified photograph in Keko Mwanga, Dar es Salam, Tanzania (Sluizas, 2004). Since there are numbers of steps involved in the processing, the image quality can quickly decrease. Hence the extreme care is required in processing these images.

Another development of high resolution satellite images (such as IRS 1C, IKONOS or QuickBird) has caught quite a bit attention. These images may become a good alternative for aerial photographs. The advantage of using these images over the aerial photographs is that firstly they cover a larger area than aerial photographs. Since the images are continuously captured, new data are quickly be processed and loaded to the databases for maintenance.

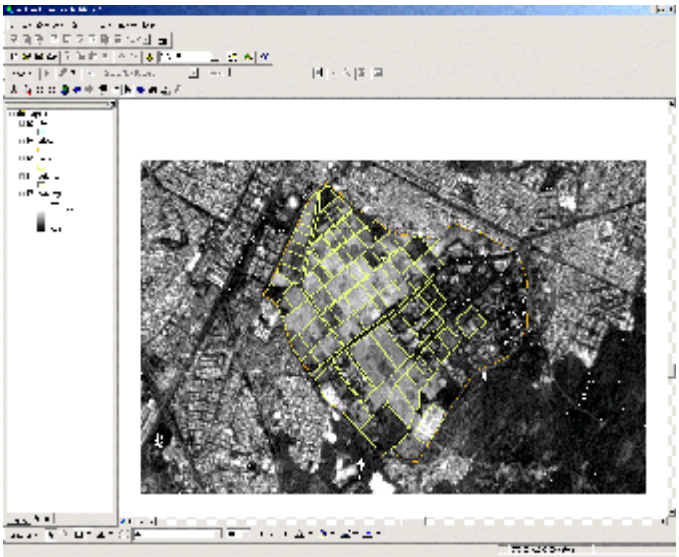

Figure 4: IRS 1c image in GIS environment

Remote Sensing Satellite (by Indian Remote sensing Satellite) known as IRS 1c has sensors that capture image in panchromatic mode and has spatial

resolution of 5.8 m in the ground.

The case study conducted in a geo-referenced IRS 1C image shows that image may be suitable for village information system, and spatial objects so detected can be digitized. They can be linked to all kinds of social, economics, and environment data for analysis in a GIS. Of course, it is important that we do field verification. But it also suggests that it is hard to extract objects at individual parcel level. The figure 4 shows the use of IRS 1c image in ArcGIS environment.

Ground resolution of IKONOS images are 1 m for the black-and-white (panchromatic) band and 4 m for multi-spectral bands. The geometric accuracy of the raw data, orbit-corrected, the geo-corrected data on the basis of ground control, and stereo-imagery for Carterra IKONOS products are stated as ±12 m, ±6m, ±3m and ±1 m respectively (Konecny, 2002).

The case study in IKONOS Image (of ±3m geometric accuracy) in Kathmandu City indicates that the overall visual extraction of spatial objects at the parcel boundaries can be more easily done in multi-spectral bands than in panchromatic band. But spatial objects such as building, roads, rivers, and other physical objects are easily extracted from both images (Tuladhar, 2004).

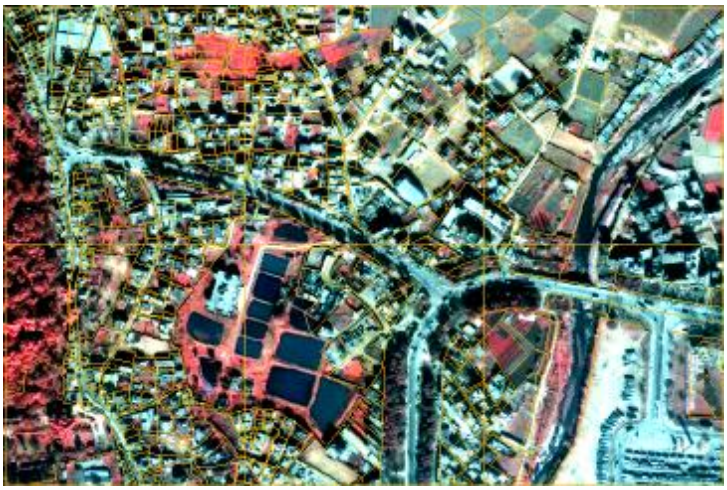

Figure 5: IKONOS image in Kathmandu area

Since the ground resolutions of Quick Bird images are 0.6 m for panchromatic band and 2.44 m for multi-spectral bands, the interpretation /extraction of spatial objects from these images may be expected to be more easily done. The figure 5 shows an example of IKONOS image of multi-spectral bands.

3.2 Application for Pro Poor Land Management

Above section 3.1 clearly shows that there are many possible way of applying orthoimages of aerial photographs or high resolution satellite images to identify and extract spatial objects that are applicable to pro poor land management. The applications are generally delineation of boundaries during participatory adjudication and community planning processes where communities, slum dwellers or informal settlers are involved. During these processes, orthoimages provides them very good overall picture of sites and their boundaries. For such processes, the images must be printed using a high quality printer so that orthophoto can be displayed for identification and marking the boundaries on the orthophoto.

The blocks, outer boundaries or individual buildings within the slums or informal settlement areas can be identified by communities themselves. They are then digitized as polygon, lines

or points (depending upon tenure rights) and the digital data can be loaded into local land information system.

Some objects may also be identified using automatic image classification technique particularly land covers that are interests to pro poor land management. There are options like unsupervised and supervised classifications. Knowledge based image analysis is rather sophisticated technique where the knowledge is applied to the image data using an inference mechanism, or sometimes and inference engine (Richards, 1993). Detail discussion about these techniques is given elsewhere and is beyond the scope of this paper.

4. CONCLUSION

This paper has firstly reviewed the essential elements of pro poor land management that allows slums or informal settlements to integrate into city planning approaches. It discusses three innovations namely new paradigm on land tenure concepts according to their norms and values, appropriate use of Geo-information technologies (GIT) in the processes of land administration e.g. determination, recording and dissemination of land information on tenure and use rights of land, Local land information systems enabling easy access to land information. This paper lastly indicates that uses of aerial photographs and high resolution images are promising and described using the number of cases applicable to pro poor land management. But the purpose needs to be carefully examined before its uses.

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BIOGRAPHICAL NOTES

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