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Educational Aspects of Remote Sensing Technology Transfer in Ethiopia and India

EDUCATIONAL ASPECTS OF REMOTE SENSING TECHNOLOGY TRANSFER IN ETHIOPIA and INDIA

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Summary. An assessment of the Ethiopian Mapping Authority (EMA) and Modern Cartographic Canter of the Survey of India concerning of the remote sensing training programs are presented. The training programs covered a wider spectrum of the theory of remote sensing technology, methodology and digital image processing as well as practical experience on the ERDAS and System 600 Model 75 of the International Imaging Systems. The program has yielded significant results.

The training programs, a component parts of the UNDP projects, have been attempted also to integrate the need and close co-operation of the user community. The staff which have been properly prepared at home have been then also trained later in Canada, Nigeria, The Nertherland and in the USA.

1. Introduction.

Efficient mapping of the territory of Ethiopia (1.2 mill. sq.km) can be accomplished only with the proper utilization of new technologies in the field of Photogrammetry and Remote Sensing.

Analogue photogrammetric instruments and visual interpretation have been in use in EMA for quite a long time for compilation of topographic maps in the scale of 1:50,000. Since 1971 up to day about 45% of the country has been mapped in that scale using analogue photogrammetric methods [10]. Meanwhile, the demand by users for elaboration of different kinds of maps is increasing rapidly in democratic Ethiopia. Therefore, EMA needs trained manpower capable of using the analytical photogrammetry methods and digital image data processing techniques for elaborating different kinds of aerial and digital satellite data.

The UNDP has assisting EMA to help establish a National Canter for Remote Sensing (NCRS) equipped with sophisticated up-to-date equipment and introducing ortophoto production.

Training program has been going on in EMA for a few years with the assistance of UNDP. The incorporation of Remote Sensing into the already ongoing analogue photogrammetry methods for map compilation was an improvement in the whole system. In this respect, the contribution of UNDP's project in the effort of upgrading the skill of EMA's staff and updating the existing

equipment with modern Photogrammetry and Remote Sensing facilities has been considerable.

2. Objectives of the training program in EMA.

The recognition of remote sensing as an important means for providing information to national resource planning and development programs has been highlighted in several conferences and workshops conducted to determine and adapt suitable training programs in the developing countries [1].

The importance of education for developing countries has been published in many scientific papers [2] [3]. Remote Sensing has been selected as one of the six fields essential for development of the South Korea [4]. Progress in education of Remote Sensing are summarized in the publication entitled "Current Trends in Remote Sensing Education" [5].

Some consultants assigned to work in Africa did not have sufficient time which should allow them to transfer the new technology and skill to their African counterparts. Usually, when the overseas assistance is terminated, the sophisticated equipment is not used by the local staff.

There is a critical shortage of geo-information on the African continent. The total area mapped at the scales 1:25,000 and 1:50,000 accounts only for about 2.5% and 3.5% respectively [6]. The net effect of the absence of latest satellite data (SPOT, Landsat TM, Soviet Space KFA-1000 and KVR-1000 photographs) in Africa in general and in Ethiopia in particular has been reflected in the low level of the production of topographic maps and thematic maps in various scales. As has been said, Remote Sensing is a valuable means that can assist in the assessment as well as monitoring of the natural resources with the ultimate objective of providing relatively low cost geo-information for decision makers at various levels. In this respect, the availability of satellite data and the necessary equipment is very important. Nevertheless, what is much more important is the availability of skilled personnel. In view of this one of the very important activities in the process of building the NCRS is the training of capable local staff. The course "Remote Sensing and digital image processing techniques for natural resources studies" has been organized for eight trainees who had been graduated in the Addis Abeba University and abroad in the former Universities in the USSR.

The main objective of the course was to provide theoretical and practical knowledge in remote sensing with emphasis on the use of digital image processing and pattern recognition techniques. A breakdown of the above objectives may be enumerated as follows:

- the provision of the necessary knowledge on the principles of Remote Sensing methods and technology, hardware and softwar components and their application to environmental sciences;
- on-the-job training on the use of analogue satellite imageries and visual interpretation for natural resources and topographic mapping application;
- on-the-job training on ground truth data collection and the use of collateral materials as supportive tool for satellite remotely sensed data analysis;
- the application areas of remote sensing and its economic benefits;
- the need for creating strong links with other departments within and outside EMA for supporting remote sensing activities.

At the end of the training participants were expected to be able:

- define and execute a project in close cooperation with users;

- carry out remote sensing activities using analogue and digital image processing methods;
- utilize variety of processing algorithms and procedures for information extraction;
- evaluate production procedure, select an appropriate tool and method to solve a particular problem;
- understand possibilities and limitations of different remote sensing satellite systems;
- provide technical assistance to users in the various economic sectors;
- provide all necessary information concerning availability of remote sensed data of Ethiopia to the users.

During the training period the participants gained good theoretical and practical knowledge that would enable them to be prepared for advanced remote sensing post-graduate courses abroad (USA, Canada, Nigeria, Holland, Sweden). Thus, the experience which the trainees would have gained from in-house training will play a significant role in servicing user needs as well as advancing their own training.

3. The Contents of the Training Program in EMA.

Technology transfer in remote sensing through training was the central aim of the UNDP projects both in Ethiopia and India. To this effect the training programs emphasized to ensure its effectiveness by integrating current theories and principles of remote sensing, analytical strategy and 'hands-on' training on high-tech equipment and software.

The training program which has been updated and revised frequently contained inter-alia, the following activities:

-theoretical subjects: physics, Boolean and matrix algebra, elements of photography and photogrammetry, elements of computer science, elements of statistics and probability, error calculation, interpolation, Fourier transformation , spectroradiometry;

-remote sensing techniques and methods used for analogue and digital image interpretation;

-methods of field data collection and interpretation of spectro- radiometric data obtained during the field work;

-use of equipment and different satellite remotely sensed data;

-visual photo interpretation of aerial and satellite photographs;

-integration of topographic maps with remotely sensed data in order to produce enhanced satellite thematic maps;

-accuracy assessment of thematic maps;

-assessment of user needs;

-formulating and running pilot projects in close co-operation with the users;

-elements of Geographic Information System (GIS);

-image analysis strategy and procedures.

Furthermore participants have attended seminars and workshops.

It was important that participants of the course have a strong academic and technical background. The course covered a vast area of different topics which were quit new to all of the trainees in EMA. All of them have at least B.Sc. degree in geography, physics or geology.

The background knowledge in these areas have been found very good therefore no any lectures were given on physical geography and others releted subjects.
The program was structured in three phases: first introductory, then intermediate level followed by advanced level. For example trainees with only introductory knowledge were not able to utilize the full potential of the ERDAS system. Lectures, demonstrations, laboratory exercises and individual project had to be given to familiarize them with selected algorithms (programs).
The following were some of the methods used in the teaching process:
- lectures;
- demonstration;
- practical training;
- consultations;
- case studies, preparing technical reports;
- seminars;
- tests/exams;
- self teaching using books, journals and elaborated by author hand-outs.

On-the-job training is an interactive system that needs adequate theoretical knowledge at every level, thus it was necessary to develop and update course curricula. This will be more important in the future because of the dynamic nature of the development of the digital image processing systems, new satellite digital data and wider applications of remote sensing.
The trainees needed to understand not only electromagnetic radiation and fundamentals of remote sensing but also strategies and alternatives in choosing properly the processing techniques, specifying appropriate software methods of assessing output data accuracy, spectral characteristics of different objects and their seasonal fluctuations and their implications on the techniques used. The different digital data formats and magnetic media used for storage satellite data, processing techniques, data enhancements, feature extraction, classifiers, computer operation systems and the like, could make the training process somewhat complicated and time consuming. The advanced techniques which included, merging of digital data sets with different spatial, spectral, temporal resolution was a very important part of the training. Knowledge of the background environment and object characteristics, their relationship to the remotely sensed data as well as to the methods chosen for classification and ground truth data collection were very important.
Remote sensing technology is multi-disciplinary and extensive in its nature that a few years are needed to train a qualified specialist who is able then to work independently without any assistance. A profound understanding and skill can be gained as the experience of the specialists build-up and access to latest professional publications is made available.
Experienced instructors play key roles in such a training program where the thrust is on technology transfer and that participants are expected to be productive in their work while undergoing training. Occasionally some assistance was necessary from university or other departments to give lectures in the supportive subjects. Knowledge of fundamental photo interpretation principles and colour theory was also necessary for teaching digital image processing and pattern recognition. Visual interpretation still remains an absolute prerequisite to digital image processing. Experience in visual image interpretation of aerial photographs (panchromatic, infrared, false colour, thermal) and colour composites of satellite imageries

was necessary.

Image analysis strategy consists of a set of different algorithms, collateral data collection, field checking, selected by analyst in close cooperation with end users to accomplish particular task, and applied in a specific logical sequence to achieve mapping objectives, designing and implementation of image analysis strategies aimed at the desired objectives (mapping) have been realized through close cooperation with users.

The following image analysis procedures proposed by P.R.Baumann [5] has been adopted in a few pilot projects in Ethiopia:

- define project objectives in close cooperation with users;
- be familiar with the study area;
- acquire the collateral materials (maps, aerial photographs, statistical data, etc) concerning the study area;
- define classes in close cooperation with users;
- select types, date of acquisition, media, quantity etc. of the remotely sensed data;
- select appropriate analysis techniques and logical analysis strategy to elaborate the raw digital data;
- perform necessary ground truth data collection and in situ measurements;
- conduct preprocessing and feature extraction;
- conduct unsupervised classification and assess the results;
- perform analysis on the basis of feature statistics and assessment of the result obtained in unsupervised classification;
- perform supervised classification;
- choose the right colours from available pallets for each class according to user demands and cartography standards;
- print thematic maps and statistical data;
- assess accuracy of the output which have been produced; and
- elaborate final and technical reports.

To perform these jobs, the trainees need to be taught not only the techniques of digital image processing, but also the identification, systematic and orderly utilization of the appropriate programs available in digital image processing systems used. They were also warned to pay close attention to the objectives and demands specified by the users.

Both visual image interpretation and digital image processing have been used in a few pilot projects ran by the trainees. It has been observed that the training program objectives have been achieved with the application of the aforementioned techniques. There may be a few other techniques and strategies that can be applied to accomplish successfully mapping of a given area. However, this does not mean that a COOK-BOOK approach is available for designing map analysis strategies. Before any strategy can be adopted, the objective of the project must be defined in consultation with the users.

A great emphasis has been placed by the trainees on understanding the nature of the digital images processing software and characteristics of spectral interaction of the features of different objects. Graphs and histograms of spectral mean values, standard deviation and correlation of data associated with digital processing of the remotely sensed data have been analyzed before a proper classifier was used.

Handouts which had been prepared as teaching materials have proved quite useful in

providing a lot of information contained in a single source and compiled from a number of latest source materials. The trainees who underwent the programme are involved in resource mapping and monitoring in Ethiopia.

Lectures have been scheduled usually for all trainees from Monday through Friday two hours daily. The practical training with ERDAS has been going on with two students taking part at a time while others were working with either analogue equipment or with stand-alone computers. Reading assignments and preparation of technical reports were organized. Periodical tests/exams were also given to assess the progress of the individual participants.

4. Transfer know-how to the staff in MCC in India.

The main objective was to establish a fully operational Remote Sensing Unit in the Modern Cartographic Canter of the Survey of India capable to producing digitally image maps and updating topographic maps up to the scale 1:50,000 using satellite data. The MCC has been equipped very well with latest digital image processing software and UNIX/VMS based computers.

The main consultant's activities were concentred on the following::

- the theoretical and on-the-job training with emphasis on the use of digital image processing and pattern recognition techniques on the System 600 of IIS using digital satellite data;
- formulation of the Standard Operation Procedures and flowcharts in order to produce different kind of outputs;
- formalization of a production line for updating digitally of the topographic maps in the scales 1:100,000 and 1:50,000 using processed satellite data on the System 600 Mode 75;
- preparing the staff for training abroad.

Theoretical and practical training contained among others:

- elements of matrix algebra, statistics and probability;
- Fast Fourier Transform for filtering noise and enhancement/extraction of the topographic features;
- digital image media and data formats;
- radiometric and geometric corrections;
- georeferencing satellite data to topomaps;
- filtering and enhancement in spatial domain;
- image classification and accuracy assessment;
- spectroradiometric characteristics of different categories which should be mapped on the topographic maps;
- field data collection and verification of the classified maps;
- extraction digitally of the topographic features from satellite data;
- integration of the topographic maps with satellite image;
- System 600 Model 75 of IS software(about 450 programmes);
- transfer of the extracted topographic features to the SysScan system and filmwriter Optronics 4040/MATRIX 3000;

- satellite image map production in scale 1:50,000.

5. Results Achieved

The main objectives in MCC in India have been achived. Trained staff have improved "know-how" and acquired practical experience on the use satellite digital data for producing satellite image maps, performing classification of multispectral data and extraction of the topographic features for updating topographic maps digitally. In the end of this rather short consultancy the staff were also able to run properly more than 440 different software of System 600 Model 75 of the IIS.

The application of remotely sensed data to agricultural, forestry, urban planning, natural vegetation assessment, water resource, environmental monitoring, etc. will certainly help the economic planning and development activities of the democratic Ethiopia.

The NCRS in EMA is still in the process of development due to fast development new technic and technologies in Photogrammetry and Remote Sensing. Any institution building would require the fulfilment of the three basic system components, namely skilled manpower, necessary equipment with proper software and know-how (technology). The NCRS is trying to satisfy these conditions through technical assistance such as the one it received from the UNDP and by convincing the government about the important role remote sensing can play in resource management so that they allocate the budget necessary to run its operations.

The Canter is now in a position to provide remote sensing services to the various economic sectors in the country. The personnel trained under this program not only help in speeding up the process of broadening the resource information data base of the country, but also serve as cadres to promote the usefulness of remote sensing in the country. The EMA values the training program as a great success because it has been implemented in a very economic way. One expatriate remote sensing expert could impart his knowledge with eight local personnel. EMA would have found it very difficult, if not impossible, from the standpoint of funding, to send say eight people overseas for similar training. The personnel have been trained on equipment which they will be using for actual production thus making the transition from training to production much easier and in the personnel's own local working environment. The pilot project areas were chosen in Ethiopia which is also an advantage for maintaining consistency in feature interpretation when it comes to actual work. In fact, it was worthwhile to note that some of the pilot projects are being used for actual applications.

Eight qualified specialists in remote sensing are able to produce thematic maps on the basis of different remotely sensed data. More over the users in the various agencies have now confidence in the professional services they would got from the NCRS. However, EMA realizes that lot

more has to be done in order to make the Canter a fully-fledged remote sensing institution. From that time new updated software have been available running on the powerful computers in the UNIX operation system. Also new remotely sensed data with better spatial and spectral

resolution are on the market. High resolution (2 meters) Russian space photographs are used in Europe for topographic map updating and generation digitally B/W satellite image maps up to the scale 1:10,000 or with Spot XS data colour satellite maps in the scale 1:25,000 [8], [9].

New satellite systems like Earth Watch and Space Imaging with 3 m and 1 m pixel size of panchromatic mode and with along track stereo (Stero Fore/Aft) capability will be soon available in digital format. These data instead of small scale aerial photography can be worldwide used soon for topographic mapping up to the scale 1:10,000.
Transfer of these new technologies and the use of new professional software is required in order to speed up map production in Africa.

6. Conclusion

The building of a fully operational Remote Sensing Canter starting on a clean slate is a difficult job. The situation has been felt in the process of the training as, at first, the objectives of the programs did not materialize as anticipated earlier by UNDP. However, considerable amount of job has been done. Much more also awaits to be done in the future by way of strengthening the Canter in EMA with appropriate upgraded hardware and latest software as well as training staff to meet the ever expanding requirement of the user community for remotely sensed map based products.
In the coming years Remote Sensing, Photogrammetry and GIS technologies are going to merge with the view to solving complex spatial problems and the management of natural resources. The use of Remote Sensing in providing timely and reliable environmental data is being appreciated in Ethiopia and India. The results achieved through this training programs will, no doubt, assists the promotion of the Remote Sensing technology especially in Ethiopia. Future action should focus on consolidating the gains of the program and add new dimension by introducing the Geographic Information System which are also supplied by the Photogrammetry and Remote Sensing.

Further assistance from UNDP will enable the EMA and MCC to keep their expertise up-to-date and strengthen the capability of the new software and new satellite data properly.

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BIBLIOGRAPHY

1. ESCAP. Report on the expert group meeting on remote sensing. Training and education in the ESCAP region. Bangkok, March 1986.
2. Ayeni, Oldbodun. Digital Mapping and GIS Education in Developing Countries. ISPRS Comm. VI, Vol. XXXI, B6, pp.1-6, Vienna, 1996.
3. R. Groot, C. Pavesi. Education in Photogrammetry at ITC. A new program. IAPARS, Kyoto, 1988.
4. Ahn, Chul-ho, Yen Bock-Mo. Training and education for Photogrammetry and Remote Sensing in Korea. IAPARS, Kyoto, 1988.
5. Current trends in Remote Sensing education. Geocarto International Canter, Hong Kong, 1989.
6. Asfaw Fanta. Mapping in Africa, constraints and prospects. Addis Abeba, 1991.
7. R.A.Schowengerdt. Techniques for image processing and classification in Remote Sensing. Academic Press Inc., Florida 1983.
8. Kaczynski R. Producing First Satellite Image Maps of Warsaw. Earth Observation Magazine. USA, March 1995, pp.31- 34.
9. Kaczynski R. Satellite Image maps of Warsaw in scale from 1:50,000 up to 1:10,000. ISPRS Comm. IV, Vol. XXXI, Part B4, pp. 403-406, Vienna 1996.
10. Hadgu G.Medhin. National report. Ethiopian Mapping Authority - Looking Into the Future. ISPRS Vol. XXXI, N, pp. 19 -20, Vienna 1996.