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United Nations/European Space Agency/International Centre for Integrated Mountain Development Expert Meeting on Remote Sensing Projects for the Hindu Kush-Himalayan Region

(Kathmandu, 6-10 March 2006)

Contents

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I. Introduction

A. Background and objectives

1. In its resolution entitled "The Space Millennium: Vienna Declaration on Space and Human Development",[1] the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) recommended that activities of the United Nations Programme on Space Applications promote collaborative participation among Member States at both the regional and international levels by emphasizing the development of knowledge and skills in developing countries and countries with economies in transition.

2. At its forty-seventh session, in 2004, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposiums and conferences planned for 2005.[2] Subsequently, the General Assembly endorsed the United Nations Programme on Space Applications for 2005 in its resolution 59/116 of 10 December 2004.

3. Pursuant to resolution 59/116 and in accordance with the recommendation of UNISPACE III, the Office for Outer Space Affairs of the Secretariat, within the framework of the United Nations Programme on Space Applications, organized a five-day Expert Meeting on Remote Sensing Projects for the Hindu Kush-Himalayan Region, in Kathmandu, from 6 to 10 March 2006. The Expert Meeting was co-sponsored by the European Space Agency (ESA) and the International Centre for Integrated Mountain Development (ICIMOD), in cooperation with the Ministry of Population and Environment of the Government of Nepal. The Expert Meeting consisted of a training course (6 and 7 March 2006) and a workshop (8-10 March 2006).

4. The primary objective of the Expert Meeting was to implement a new module for the ESA Eduspace programme, entitled "Himalayas from Space", which contains appropriate case studies, further evaluated and interactively improved at the Expert Meeting. Participants also worked on their respective project proposals, in cooperation with the instructors, and continued to improve the design of their respective case studies. The Expert Meeting also reviewed some satellite-based remote sensing projects relevant to the Hindu Kush-Himalayan region.

5. The Expert Meeting was a follow-up to the United Nations/Austria/Switzerland/European Space Agency/International Centre for Integrated Mountain Development Workshop on Remote Sensing in the Service of Sustainable Development in Mountain Areas (see A/AC.105/845), which was also hosted by ICIMOD on behalf of the Government of Nepal in Kathmandu in November 2004. The Expert Meeting is a direct outcome of the Working Group on Education, Training and Capacity-building: (i) Remote Sensing in Education and (ii) ESA/Eduspace "Himalayas from Space" module, established at the 2004 Workshop.

B. Programme

6. On 2 and 3 March, ESA representatives and ICIMOD staff prepared all the necessary material for the training course and workshop and installed various softwares such as the Basic European Remote Sensing Satellite and Envisat Advanced Along-Track Scanning Radiometer and Medium Resolution Imaging Spectrometer Toolbox (BEAM), Basic Envisat Synthetic Aperture Radar Toolbox (BEST), LEOWorks and different sets of original Envisat data. The personal computers at ICIMOD were of good standard and all connected to the Internet. The speed of access to the Internet was low, however, since most bandwidth was given to the Mountain Forum organization located at the ICIMOD premises.

7. The training course was attended by 30 participants, with 8 from ICIMOD. Participants were introduced to radar imaging, including the basics on synthetic aperture radars (SARs) and the imaging characteristics of microwave, image geometry, multitemporal image analysis and basic understanding when using optical and microwave combined data sets. In the practical training, various types of software were used for viewing, processing and analysing satellite data. The Envisat online catalogue was also demonstrated and used in practical training.

8. All case study principal investigators and their respective co-workers participated in the Expert Meeting held from 6 to 10 March. The intensive individual sessions both for data access and processing and for teacher training were attended by all participants. The resulting end-of-workshop presentations of each group showed that all of the open questions had been addressed. Participants agreed to finalize the case studies in September 2006. Recommendations were developed during the last session. ICIMOD presented its view on the case studies. On the final afternoon, participants visited the ICIMOD Demonstration and Training Centre in the south of Kathmandu.

C. Attendance

9. Forty participants from the following countries and international organizations attended the Expert Meeting: Austria, Bhutan, Denmark, India, Nepal and Switzerland and ICIMOD and the Office for Outer Space Affairs.

II. Summary of presentations

10. The paragraphs below contain summaries of the presentations made by participants on 11 case studies selected by ESA and ICIMOD.

1. Monitoring glaciers and glacial lakes

11. It was reported that Himalayan glaciers were melting fast as a result of global warming and climate change. The Himalayas contained the largest store of water outside the polar ice caps, fed seven great Asian rivers and sustained a large part of the world’s population.

12. If the glaciers were to melt at an alarmingly fast rate, it would result in catastrophe. It would first increase the volume of water in rivers, causing

widespread flooding. The situation would then reverse, leading to a decline in the level of water in rivers, leading to massive ecological and environmental problems in countries such as Bangladesh, Bhutan, China, India, Nepal, Pakistan and the countries of the Mekong basin.

13. The proposed area of study was at Lunana in the north of Bhutan, where a few of the lakes faced potentially dangerous conditions as the rate of melting of the glaciers was very high. The geographical location of the site was between 90° 0' and 90° 20' E and 28° 0' and 28° 10' N.

14. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, prepare raw images or colour composites of satellite data and vector maps of the area in picture format for easy viewing by students;

(b) Using the LEOWorks image-processing software, include in the readymade database the digital elevation model and slope in the form of raster data, contour, land use, drainage and so on, as well as geographical information system (GIS) vector layers.

15. Students would be guided through the process of downloading and importing satellite data of the study area into LEOWorks and would become aware of the changing state of the environment and of possible related dangers.

16. The next step would be an exercise to import GIS layers and to analyse and integrate them step by step with an overlay of different layers, providing the final information in the form of statistical tables and maps. Data used for the study would be Landsat and Spot satellite data from 1994, 1999 and 2004 and recent Envisat data.

2. Impact of surface mining on the environment

17. Mining involved the commercial extraction of a mineral deposit. In most cases, the mined material was processed on the mine site into a saleable product, which was then transported to an end user or to an off-site facility for further processing. The mine extraction process was extremely variable, ranging from shallow surface operations extracting sand and gravel to deep underground mining of precious and base metals. Similarly, surface processing facilities varied from quarry crushing and screening operations to large complex sulphide concentrators. Mining and on-site processing activities could be site-specific, depending on rainfall, topography and forest cover.

18. Remote sensing methods could be used to monitor pollution from mining at reduced cost and in conformity with common standards. Faced with increasing environmental pressure and regulatory controls as a result of surface and groundwater pollution, soil contamination and instability of terrain, the mining industry needed innovative and cost-effective tools to acquire and process environmental data that provided a sound basis for sustainable economic development of the mining sector. Regularly updated information stored in databases related to mining environments was used to draw up environmental impact assessments and environmental management plans.

19. The study area lay between 89° 10’ and 89° 20' E and 26° 45' and 26° 55' N in Bhutan.

20. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, prepare raw images or colour composites of satellite data and vector maps of the area in picture format for easy viewing by students. The steps involved in working or opening different images and printing for hard copy viewing would be described in detail so that students had no difficulty in understanding the problem and the tasks involved;

(b) Using the LEOWorks image-processing software, students would be guided in the use of remote sensing data processing, information extraction on change of land use and GIS analysis and would gain awareness of changes in land degradation and measures to limit their impact.

21. Medium Resolution Imaging Spectrometer (MERIS) and the Advanced Synthetic Aperture Radar (ASAR) data from Envisat would be required to determine changes in land use in the area under study. In addition, archived data from Landsat and Spot would also be helpful.

3. Expansion of Thimpu Municipality

22. It was reported that some projections had shown that, by the year 2030, a majority of the world’s population would be living in metropolitan areas, which meant that between 2006 and 2030 rural-to-urban migration would escalate in many parts of the world. It was not clear whether urban centres could cope with the additional pressure brought to bear on infrastructure and services by the inundation of rural people looking for a better life or whether cities as centres of business, social life and culture could offer solutions to those challenges. With the increase in population and the rural-to-urban migration there would be a scarcity of adequate accommodation in many urban cities.

23. Thimpu would be the base of the case study. The geographical location of the site lay between 89° 35' and 89° 45' E and 27° 25' and 27° 30' N.

24. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, prepare raw images or colour composites of satellite data and vector maps of the area in picture format for easy viewing by students. The steps involved in working or opening different images and printing for hard copy viewing would be described in detail so that students had no difficulty in understanding the problem and the tasks involved;

(b) Using the LEOWorks image-processing software, students would be guided through the process of downloading and importing satellite data of the study area into LEOWorks.

25. The next step would be an exercise to import GIS layers and to analyse and integrate them step by step with an overlay of different layers, thereby providing the final information in the form of statistical tables and maps and demonstrating the rapid and increasing growth of the city and the lack of additional infrastructure.

26. MERIS and ASAR data from Envisat would be of much help in detecting change. In addition, archive data from the Indian Remote Sensing Satellite (IRS),

Landsat and Spot would also assist in detecting and assessing the change over the period under study.

4. Landslide mapping and hazard assessment

27. In mountainous regions around the world, landslide hazards and associated flash floods created havoc in the lives and properties of the people living in those regions.

28. Physically it was difficult, risky and time-consuming to map active landslides and assess the hazard associated with them. With the availability of the data generated by sensors and cameras mounted on Earth resource satellites and air-borne cameras, the task of geoscientists had become much easier, faster and more cost-effective. It might not be possible to prevent landslide hazards, but, based on knowledge of the hazard, disasters could be mitigated.

29. The geographical location of the case study site in Bhutan was between 89° 20' and 89° 30' E and 26° 45' and 26° 55' N.

30. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, students would get acquainted with the various terms used in the case study before they worked on the exercise. Students would either get an individual copy of the topographical map of the study area or a larger-scale single copy would be pasted on the wall of the classroom. A soft copy of the map would be made available in downloadable format. Raw and rectified satellite images would then be displayed on the computer screen. The exercise would contain questions to ensure that students understand, interpret and identify features visually. They would also be asked to compare the base map and different satellite data;

(b) Using the LEOWorks image-processing software, students would be guided through the process of downloading and importing into LEOWorks satellite data on the area under study.

31. The next step would be an exercise to import GIS layers and to analyse and integrate them step by step with an overlay of different layers, providing the final information in the form of statistical tables and maps, in order to demonstrate the usefulness of satellite data to monitor and assess the danger in a given area.

32. MERIS and ASAR data from Envisat would be used during the case study. In addition, the archived multi-temporal data from Landsat and Spot would assist in assessing landslide events in previous years.

5. Air pollution in the Kathmandu valley

33. Any contamination, natural or anthropogenic, of ambient air was known as "air pollution" and its causing agents were known as "air pollutants". According to the World Health Organization, air pollution was limited to situations in which the outdoor ambient atmosphere contained materials in concentration, which were harmful to man and his surrounding environment. Basically there were six classic air pollutants present in the ambient air: carbon monoxide, ozone, oxides of nitrogen, sulphur dioxide, lead and particulate matter.

34. Air pollution was a growing problem, especially in urban areas, because of the increasing use of fossil fuels, primarily for transportation. Unmanaged urban settlements had also compounded the problem. It was also not a new phenomenon in the Kathmandu valley.

35. The Kathmandu valley study area covered an area of approximate 667 square kilometres. It was roughly elliptical in shape, 25 kilometres along its east-west axis and with a maximum width of 19 kilometres. It lay in the lesser Himalayas of central Nepal, between 27° 32' 13" N and 27° 49' 0" N and 85° 11' 31" E and 85° 31' 38" E and at a mean elevation of about 1,350 metres above sea level.

36. The following exercises were suggested for students in order to achieve the desired goal: (a) determine trends in levels of air pollution in the Kathmandu valley; (b) compare those levels at different places in the valley; and (c) compare and correlate seasonal variations in air pollution information extracted from satellite images with the ground data from the valley.

37. Simple measurements in the field would be supplemented by meteorological observation data from the existing monitoring stations and interpretation of temporal satellite images in order to raise awareness of air pollution and to provide an opportunity to play an active role in quantifying air pollution. MERIS data from Envisat would be used in the case study.

6. The concrete jungle: a tale of two cities

38. It was stated that a city was an entity in a league of its own. It took years and decades, sometimes even centuries, for it to grow and mature. Often with the passage of time, the trials and tribulations that a city was faced with started to magnify. Many cities in India threatened to burst their seams. In a few, an attempt was being made to re-establish the balance between the city and its environmental milieu through conscious, planned efforts. For others that were not so lucky, life continued and the friction caused by unplanned growth reached extreme heights. Often a city's burgeoning population, activities and their environmental impact continued to grow and increasingly accelerated demands were being made on the city's landscape and its immediate hinterland.

39. The study would centre on two cities, Guwahati (26º 10' 45" N by 91º 45' E), the capital of the State of Assam, and Shillong (25º 30' N by 91º 40' E), the capital of the State of Meghalaya. One was centuries old, while the other was a little over one century old. Both had experienced rapid but uncontrolled growth in recent decades. Disconcertingly, neither city's expansion had been properly inventoried.

40. Beyond the city of Guwahati, forest areas such as Rani and Amchang, which were forced to host spillover population from the city, were also adversely affected. Forest losses in the two hinterlands had been quantified between 1991 and 2003. The effect of railway lines emanating from the city (and also near Amchang) that caused elephant fatalities would be assessed.

41. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, Global Positioning System (GPS) readings from a field study would be used by students to locate various categories of land use on processed SAR and Landsat images;

(b) Using the LEOWorks image-processing software, the exercises would include the construction of a GIS, based both on measurements in the field and on processed images.

42. SAR data from Envisat and optical data from Landsat would be used in the case study.

7. Remote sensing/Earth observation for wildlife habitat monitoring: a case study of the Royal Bardia National Park in Nepal

43. The Royal Bardia National Park encompassed a wide diversity of habitat and mainly undisturbed wilderness areas in the Terai and Siwalik regions of Nepal. It was a habitat mosaic of dominant sal (*Shorea robusta*) forests, riverain forests, mixed forests, grasslands, savannas and wetlands. The Park, drained by the Karnali and Babai rivers and their tributaries, was an excellent habitat for many globally endangered species, including the tiger, rhinoceros, wild elephant, Gangetic dolphin, Bengal floricon and lesser floricon. The livelihood of the people living in the buffer zone of the Park depended on forest resources. The establishment of the Park in 1976 was a major biodiversity conservation effort of Nepal. Anthropogenic and natural ecological factors had effects on wildlife associated with land cover change. On that basis, the proposed case study would assess the status and distribution of land cover and habitat suitability for a large variety of fauna.

44. The study area covered 968 square kilometres between 28° 15' and 28° 44' N and 81° 10' and 81° 45' E.

45. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, study the different colours based on processed images and define areas according to the different types of land cover, such as forest, grass land, agricultural land, rivers and river beds; and to study changes from 1990 to 2002 to show the distribution of animal sitings and places of conflict with the local population;

(b) Using the LEOWorks image-processing software, construct natural and false colour images to analyse land cover in the area.

46. The exercises would include the use of different GIS layers in combination with Landsat and Envisat MERIS data to describe and analyse the area. Different calculations would be performed by students to quantify the conflicting interests. A focus of the case study would be to find where human activities would most likely clash with wildlife populations. MERIS data from Envisat would be used in the case study, together with Landsat images from 1990, 2001 and 2002.

8. Disastrous flash floods in Himachal Pradesh, India: a case study of the Satluj river basin

47. It was reported that Himachal Pradesh was a mountainous province in the Indian Himalayas covering an area of over 50,000 square kilometres, where mountains and hills occupied most of the land. Geographically, the State of Himachal Pradesh was situated between 30° 22' 44" and 33° 12' 40" N and 75° 45' 55" and 79° 04' 20" E.

48. The State's hydrology could be described as four major river basins, namely, the Ravi, Beas, Chenab and Satluj, which originated in the snow-clad Himalayas. Given its unique locational and geographical setting at the northern-western fringe of the youngest mountain chain (the Himalayas), Himachal Pradesh was one of the major disaster-prone states in the country as regards earthquakes, flash floods triggered by cloudbursts and glacial lake outburst floods, landslides, avalanches and forest fires. Recent large annual fluctuations in river discharges clearly represented varied physical and climatological characteristics consistent with climate change.

49. The area enclosed in the Satluj river basin consisted of parts of the districts of Lahaul and Spiti, Kinnaur, Shimla, Kullu, Mandi, Hamirpur, Bilaspur, Solan, Sirmaur and Una. That area extended from 30° 22' to 32° 42' N and 75° 57' to 78° 51' E.

50. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, to locate and describe the course of the Satluj river in Himachal Pradesh using an atlas together with processed satellite imagery; describe which areas had been hit the hardest by floods and comment on why areas were affected so differently; and study the extent of the floods, based on the study of the satellite images;

(b) Using the LEOWorks image-processing software, analyse satellite images using the different tools of LEOWorks; and superimpose different GIS layers on the satellite imagery in order to study, among other things, why the floods developed so disastrously.

51. The following data would be used: IRS data together with a collection of GIS layers; and SAR and MERIS data from Envisat.

9. Flood assessment in the southern plains of Nepal

52. It was reported that every year during the monsoon season (usually from mid-June until mid-August), there were many landslides in the mountains and floods in the plains, and hundreds and sometimes thousands of lives were lost as a result of such floods. There was also major loss of property and infrastructure, such as by the washing away of agricultural crops and destruction of houses, bridges and highways.

53. Satellite remote sensing provided a practical way of assessing such floods on a scientific basis; however, since the weather was usually cloudy or rainy when there were floods, optical remote sensing, which depended on sunlight as a source of energy, had limitations in such studies. It was therefore proposed to prepare a case study on flood assessment using radar (microwave) remote sensing, which could obtain data under any weather conditions and at any time of the day or night.

54. A flood plain area in the Terai region of Nepal, just south of the foothills of the mountains, would be chosen for the case study. The area was about 100 kilometres south of Kathmandu.

55. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, provide a ready-made worksheet with an image of a flood situation and a land-cover map to allow assessment of the damage;

(b) Using the LEOWorks image-processing software, use data and instructions to classify a multitemporal SAR image.

56. Data to be used were ERS-2 or Envisat ASAR from 2002 and 2004, together with Landsat and aerial photographs, digital elevation models and rainfall data.

10. Monitoring of glaciers and glacial lake development in a high mountain environment: examples from the Khumbu Himal area of Nepal

57. The environment was reportedly changing its appearance permanently. Especially in ecological fragile areas such as the Himalayas, that could have a considerable impact on the ecosystem. Additionally, global warming and human influence could accelerate the consequences.

58. The world's highest mountain range was also home to a very large number of glaciers. People in the Himalayas had adapted to the unique living conditions in the region, but they had also settled in areas that were becoming or had already become endangered over the years. Glacial lakes could become a risk for people living in such areas in the case of an outburst.

59. The objectives for the potential user of the case study were as follows: (a) to gain a basic geographical knowledge of glaciers, their behaviour in relation to climate change and the risks to human beings; (b) to explore and understand the appearance of glacier-related features in different remotely sensed data (wavelengths); (c) to examine the processing and enhancement of optical data; (d) to acquire knowledge of low-level classification routines; (e) to build up competence in creating and integrating GIS data structures by means of digitizing glaciers and glacial lakes in topographical maps and image data; (f) to visualize and analyse time series; and (g) to gain more knowledge about the relationship between glaciers and high mountains and climate as regards disaster risks.

60. The study would focus on the southern Khumbu Himal area, especially the Imja and Honku glacier region in the south of Lhotse (8,501 metres) and Ama Dablam (6,856 metres) in Nepal.

61. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, produce a pictoral demonstration of rapid glacial melting and related problems;

(b) Using the LEOWorks image-processing software, visualize RGB colour model images and analyse the spectral profiles of different types of forest and land cover. The visualization of time series, together with the creation of GIS layers, would be used to analyse changes in land cover.

62. Envisat MERIS data, together with data from the Landsat Multi-Spectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+), and aerial photographs would be used.

11. Environmental problems in the Himalayas: a special focus on Nepal

63. The environment surrounding the Himalayas was fragile. Their weak ecosystem was quite vulnerable because of recent developments and changes. In recent decades, especially in Nepal, a number of environmental problems had emerged, the major ones of which were caused by land degradation, deforestation

and pollution. Deforestation had a socio-economic impact, namely a decrease in wood production, agriculture and biodiversity, resulting in natural disasters and damage to the cultural heritage of the indigenous people. Urbanization caused damage to the natural environment and increased the risk of disease for human beings.

64. The objectives for the potential user of the case study would be: (a) to gain a basic geographical knowledge about forests, as well as the vulnerable ecological environment of Nepal; (b) to explore and gain a better understanding of that environment; (c) to examine the processing and enhancement of optical data; (d) to learn low-level classification routines; (e) to visualize and analyse time series; (f) to gain more knowledge about the relationship between human activities and the natural environment; and (g) to strengthen knowledge by answering a questionnaire.

65. The study area was affected by the general environmental problems of Nepal. For specific examples, different study areas would have to be selected (e.g. for deforestation: the degraded and/or deforested areas in the Terrai, Middle Mountains and High Mountains) jointly by experts from Tribhuvan University and ICIMOD.

66. The following exercises were suggested for interested students:

(a) Without using the LEOWorks image-processing software, present the changing ecological situation in the form of a time series of satellite images showing the human pressure on nature;

(b) Using the LEOWorks image-processing software, quantify land cover changes and assess the consequences.

67. Envisat MERIS data together with Landsat MSS, TM and ETM+ would be used in order to set up a time series of satellite images.

III. Recommendations

68. In view of the success of the Expert Meeting (training course and workshop), participants recommended continuing such activities for educational purposes, in particular, for secondary school and university teachers.

69. Participants requested ICIMOD to inform them about any follow-up activity in that regard.

70. Use of broadband Internet was still very expensive in the region. It was much cheaper to send a large amount of data on CD/DVD by mail. Given the fact that ICIMOD personnel often travelled in the region, participants requested the delivery of data by hand or regular mail, through the Centre, since that option would be more secure than electronic delivery. However, all options should be suggested to the end-user.

71. In that regard, the Office for Outer Space Affairs suggested that a low graphic/text-only version be built into the ad hoc portal (http://www.icimod-gis.net/) at ICIMOD.

72. An invitation was made to hold the next meeting in Thimpu in 2007 in order to finalize the project on the 11 case studies. A one- or two-day course for secondary school teachers from Bhutan would be organized before the presentation of the case

studies. Teacher training could only be held during the school vacations (December-February). In order to start planning for such an event, an official invitation from Bhutan's diplomatic representation must be sent to the Office for Outer Space Affairs.

73. At the 9th International Symposium on High Mountain Remote Sensing Cartography to be held in Graz and Hohe Tauern National Park, Austria from 14 to 22 September 2006, a special session on education would be organized. One or two of the best case studies would be selected for presentation at that meeting and the authors of those case studies would be invited to the event.

74. The Office for Outer Space Affairs would organize a presentation of the case studies to the Committee on the Peaceful Uses of Outer Space at its forty-ninth session to be held in Vienna from 7 to 16 June 2006.

Notes

[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1.

[2] *Official Records of the General Assembly, Fifty-ninth Session, Supplement No. 20* (A/59/20 and Corr.1 and 2), para. 71.