LUCRĂRILE SIMPOZIONULUI "SISTEME INFORMAȚIONALE GEOGRAFICE", NR. 13.
Anal. Şt. Univ. "Al. I. Cuza" Iaşi, Tom LIII, s. II c., Geografie, 2007

POTENTIAL OF MODERN REMOTE SENSING DATA AND GIS DURING THE EVALUATION AND DETERMINATION OF DANGEROUS GEOLOGICAL PROCESSES

D.V. Zakhidova, A.A. Abdurakhmanov
Department of Geoecology, Institute of Hydrogeology and Engineering Geology HYDROENGEO

Abstract: One of the types of emergencies related to risk of human life and economic objects in mountain and submountain regions in Republic of Uzbekistan is a development of sliding processes. In order to take measures for decreasing of negative consequences of these dangerous geological processes, it is necessary to develop sliding warning system. This task requires a broad approach using not only traditional methods of research, but also modern methods of remote sensing of the Earth with the help of geographical information system.

The applications of remote sensing data and geographical information system for estimation and determination of sliding areas by the example of a pilot area located in Bostanlik area of the Tashkent region in the Republic of Uzbekistan are discussed in this article. In this region the sliding displacements formation is recorded, mainly in loess rocks. A probability of new sliding formation depends on various factors and is equal to the product of their probabilities. The most important are the slopes height, their exposition, and steepness, the form in plan and profile, confinedness to tectonic disturbances, geological structure, capacity of loess sediments and their moisture.

During the work radar satellite images from Radarsat and multispectral satellite images from were used. For the processing of different data types and formats the ArcView 3.2., ArcInfo 9.1., MapInfo 7.8., GlobalMapper 6.0., AdobePhotoshop SC v.8.0 are being used.

Some aspects of the technological processes of data processing are considered, including several basic steps: input of default information, preliminary processing, maintenance of raw and processed data archives of remotes sensing data, thematic processing (decoding and interpretation). Several problems occurred during the data processing of remote sensing data were emphasized. The following work steps in organization and fulfillment of further researches, which are necessary for complete implementation of the project and obtaining its objectives.

Key words: *geographical information systems (GIS), remote sensing (RS), sliding processes, data processing algorithms, decoding, interpretation, probability theory.*

Development of land-sliding processes in mountain and submountain areas of Usbekistan leads to emergencies related to risks for human beings and economic objects. Timely notification and providing of actual information is

essential for taking operative measures. This task requires a wide approach, using not only traditional methods of research, but also modern methods of remote sensing (RS) data with applications of Geo Information Systems (GIS). However, it is significant that the application of RS data and GIS is impossible without ground-based research and especially at the beginning of interpretation and calibration satellite images. In the last years the large spectrum of data were analyzed, including information of ground-based observations obtained during geological, hydro-geological and engineering-geological researches in regions that are subjects to land-sliding. Depending on various factors, the favorable conditions are created, which influence the development of such a dangerous geological processes as a landslide.

As a result, the employees of the institute make an effort to find out the methodology for localization of regions that are subjected to land-sliding as in Bostanlik region of Republic of Uzbekistan. This region was determined as a pilot segment where the development of land-sliding was detected. Several assumptions were used during this research. First of all, land-sliding processes are formed under the influence of polysemantic factors. Their influence on the slope stability is based on probability. Therefore, for complete forecasting of land-sliding processes the probability theory can be used as a first approximation. At the same time, remote sensing data gives the opportunity to get the important information about territory features, its location in space and time. The results of ground-based activities become more visually informative.

The investigated territory is located on the coast of Charvak Reservoir in 124 km away from Tashkent city (Figure 1). There are many landsliding that appear here mainly in loess rocks. Probability of new sliding formation depends on interaction of various factors and is equal to multiplication of theirs probabilities. The most important of those are the height of slope, its exposition, steepness, its shape in plan and profile, relation to tectonic disturbances, geological structure, capacity of loess deposits and their moisture.

At the first stage of the problem solving the most appropriate variant for application of remote sensing data (RSD) appeared to be radar images from Radarsat and multispectral satellite images from Landsat. Multispectral images have geometrical resolution, which satisfy the requirements of medium- and small-scale mapping. This data have been decided to be used on the first approximation of this task. Presently, efforts are made to provide the remote sensing data with higher resolution.

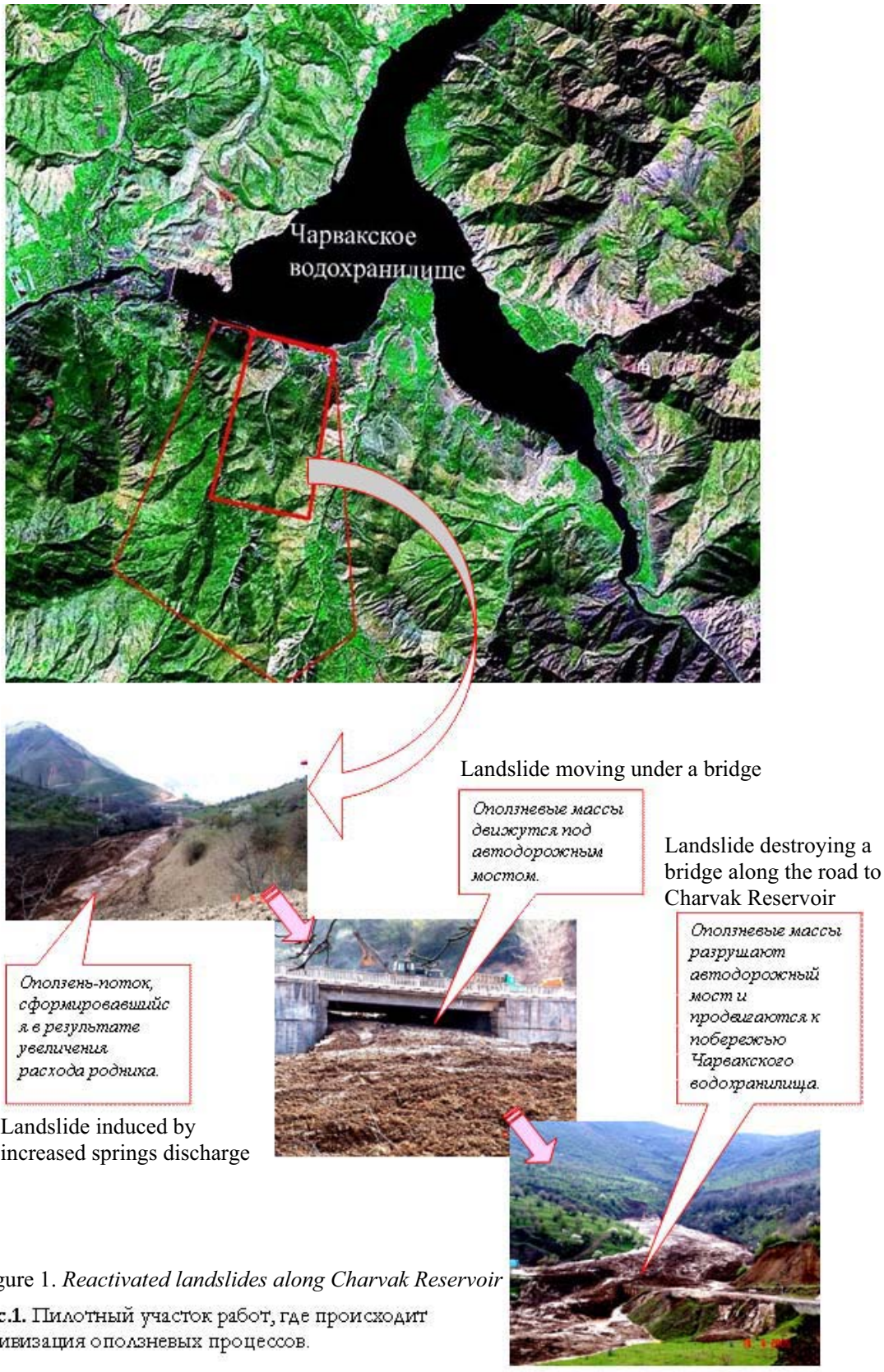

Figure 1. *Reactivated landslides along Charvak Reservoir*

Рис.1. Пилотный участок работ, где происходит активизация оползневых процессов.

Effective utilization of remote sensing data during solving problems of dangerous geological processes becomes possible only with the help of special Geo Information Systems (GIS). As a software for processing of different data types and formats we use such products as ArcView 3.2., ArcInfo 9.1., MapInfo 7.8., GlobalMapper 6.0., AdobePhotoshop SC v.8.0.

The technological process of data processing includes the following key phases:

1. Loading the input data that includes preliminary collection of geological, hydro-geological and engineering-geological (often in analog form) as well as remote sensing data. The data received by means of ground-based methods are loaded in form of attributive data table and raster-mapping materials that are further vectored and brought to an appropriate numerical data format. The remote sensing data is loaded in to the system in a form of source files received from suppliers. Diversity of information sources leads to diversity of input data formats. That's why the important part of this stage is conversion that would convert any input data in to the format supported by other software products. Often, as conversion software, GlobalMapper 6.0 can be used. At this stage it is necessary to extract the auxiliary information such as for example geographical location, from the flow of input data that is used for data calibration. The primary database related to investigate territory is generated and includes all input data provided by researchers.

2. The primary (preliminary) input data processing includes several algorithms of visualization improvement on the screen: contrasting, normalization, correction of levels in channels, scale change and other algorithms. Procedures of this stage include review of images, geographical location, geometrical correction (ortoretification), preservation of fragments, various forms of export, and when necessary mosaic arrangement. These procedures refer to mapping materials as well as to the satellite images.

3. Maintenance of the local archive containing the remote sensing data where the satellite images are grouped according to different characteristics: captured area, resolution (low, medium and high), captures spectrum (visible, infra-red), etc. The results of this stage can be used with a view to create a mosaic of required territory for further processing of remote sensing data that accelerate and facilitate the process of interpretation of subject matters of the natural-man-caused system.

4. Maintenance of the local archive containing processed remote sensing data where satellite images are grouped according to features different from the local archive containing the input remote sensing data. In this archive, the data

processed using different algorithms are placed. They provide the intermediate and/or final results of the work.

5. Thematic processing (interpretation) is generation of thematic maps or layers of Geo Information Systems (GIS) based on thematic interpretation of remote sensing data. At this stage logic and arithmetic operations, classification, filtering, lineament analyses and other methodical techniques are carried out. Also visual interpretation of images on PC screen, which is realized by means of «drawing mouse», stereo effect, and the whole arsenal of image processing and transformation techniques may also be used. An image is depicted on the PC screen in form of pixels of certain size (256x256, 512x512 and others). Every pixel has its own value of brightness, which depends on character of the underlying surface and objects on it. Atmospheric changes distort the image brightness. The processing is oriented on elimination of these distortions and intensification of brightness differences of objects that are subjected to interpretation. There are four arithmetical operations: adding, subtraction, multiplication and integer division of two images obtained in different spectral channels. The areas of images with brightness that exceed the required diapason are filled with a color (for example red). This allows the visual control of arithmetical operations. Logical operations, which are realized on automated image processing platforms, are usually 7: conjunction, alternation, equivalence, inversion, negation AND, negation OR, exclusive OR. An image filtering is used for quality improvement, elimination of noise and extracting of interesting objects. A principle of filters operation represents transformation of brightness values at each point based on information about brightness of their neighbors in any other quite bounded territory. As a rule, the image is filtered with the help of matrix of certain size, which coefficient can be assigned arbitrarily. As a rule, the value of the sum of coefficients takes into account the signs and is normalized according to data format in the way that there is no exit over the area of permissible values. Particularly, using assigning of coefficients it is possible to increase the contrast. Occurred areas that are not completely filled or overfilled get boundary values corresponding to given format. Ripple filters (Average, Brown, Median, Lev, Nagao, Graham and others) allow eliminating a noise and to obtain homogeneous parts of images that are useful for further processing for landscape or structural groups extraction. Filters that underline the brightness are used for detecting the boundaries between the objects on the image, for example between different structural regions and while exposure discontinuous disturbances. Several filters refer to this group: Sobel, Sharp, Prewitt and others. Often a binarization operation is used during automated

geological interpretation according to predetermined threshold value. A binarization is the transformation of grayscale image into a binary image. All pixels of the image with brightness's higher than the predetermined threshold become white and the others – black. The threshold is chosen after study of the intensity distribution on the objects of interpretation. Variation of a binarization threshold allows extracting the objects and the information about intensity distribution - to conduct the interpretation of distinguished objects. The images can be morphologically transformed which often can be very useful during an allocation the objects that are not enough interpreted. Wide opportunities are provided using automated classification of multispectral images (with the preliminary study of models or with assigned parameters). The classification is based on the fact that various natural objects have different brightness in different electromagnetic spectrum. The analyses of the object brightness in different zones allow identification and contouring of landscapes, structural-material objects and specific geological and man-caused phenomena. A big amount of linear elements that represent lines of the exit of discontinuous structures is interpreted on the images. Studying them is important for the analyses of sliding processes. The large number of allocation and linear structures leads to serious difficulties in interpretation as well as in correlation of the lineament system of different spreading, identification of structural patterns their space spreading and specifics of manifestations in different natural zones. The application of automated allocation and analyses of lineament allow eliminating above listed difficulties. It gives more opportunities and is carried out quicker. Satellite images interpretation data are exported in to the GIS where they are preserved together with the mapping information in form of layers. The complex interpretation of data of the interpretation (expert's estimation) is carried out by means of their comparison with geographical, geophysical and other maps in GIS. As a result the natural complexes reveal interpretation signs that generate certain background of a territory subjected to seasonal variations. Ascertainment of non-typical modifications of interpretation features allows registration and estimating landslide processes. Filtering of initial images and lineament analyses allow to find out and evaluate a modern side-breaking structure. Density maximum of the lineaments points in more intensive areas of lithosphere and the analyses of intensity lineaments allow to outline the breaks – possible sensitizes of the landslide processes. Various software tools allow maintaining such operations as image size changing, color contrasts, texturing and automatic measurement of areas and statistical characteristics of the areas with unstable geological environment. More dangerous areas subjected to

disastrous landslide processes as a result of different degree of loess deposit disturbance resulted from different processes refer to them. With the help of software tools the "landslide-not landslide" is identified interactively, by means of binarised image fragments. These slope areas, characterized by gravitation instability, are subject to development of landslides.

A combination of comparable maps developing base maps and series of transparent maps of changing elements and processes are used to obtain more precise values. Analysis of maps, made in different time, allows detecting changes and different kinds of movements: slow, fast, jumping, episodically and periodically changed.

In conclusion, it was identified to be necessary to point out the problems that appeared while processing remote sensing data:

✓ First of all, there is a lack of updated topographical maps that introduce errors in image location.

✓ There is a big demand for increasing disk memory space. For example, an image of 15-meters resolution occupies 250 Mb. To save one processed image with intermediate result it is required to have 10-15 times more of memory space.

✓ The images from Landsat were bought for the whole research territory. Having images with different climate conditions and periods of landslide activation the spring-autumn images which provide the most-full picture of landscape are preferred. But these images as a rule are with a large percentage of nebulosity.

✓ Existence of clouds and their shades is prevented due to the fact that the clouds and sand, clouds shades and the water coincide in spectral characteristics, often the correct classification of the images.

✓ Insufficient resolution of the images (30 meters per pixel) doesn't allow pointing out the boundaries of small settlements and small landslide solids that sometimes are necessary for the content of the thematic maps.

The next phases in organization of researches must be:

- Generation of numerical map with landslide probabilities and the maps with landslide risks in Bostanlik territory of the Tashkent region in the Republic of Uzbekistan according to attributive data set.
- Further work with attributive information of database as well as replenishment of the local initial archives and the processed remote sensing data.
- Providing with essential and operative remote sensing data.

- Generation of automated maintenance of the operative imagery on the maps with changing situation, updating mapping materials and issue of further recommendation to the management.
- Development and admission of justice and financial rules for the data application of the system based on access differentiation to different types of information taking into account the requirement for the confidential regulations.
- Deployement of special department or center under the State Geological Committee and Mineral Resources of the Republic of Uzbekistan, responsible for the work of the system.

Presently, the efforts of the employees of the laboratory „GeoEcology“ of the State Institute GIDROINGEO are directed to realization of above stated activities and development of the first electronic GIS pilot project called „Landslides“. The solution of existing problem is very important for all citizens living in landslide regions. We hope that our efforts open the new horizons for solution of prevention of dangerous geological processes and give the essential recommendations for the government of Uzbekistan.

References

Diana Zakhidova, Pulat Mavlyanov, Akbar Abdurakhmanov./Complex approaches of study and detecting landslide areas in mountainous pilot areas of Uzbekistan using remote sensing data and GIS techniques/International Conference on Remote Sensing and GIS. 2007.

Turrabbaev A.T., Kamaletdinov R.G. The reports of Bastanlik station for the years 1994-1997 «The results of observation for dangerous geological processes in mountain and sub-mountain areas of Bostanlik and Parkent in Tashkent region».

Kamaletdinov R.G. The reports of Bastanlik station for the years 1997-2000 «The results of observation for dangerous geological processes in mountain and sub-mountain areas of Bostanlik and Parkent in Tashkent region». 2005 г.

Potorjinsky M.G., Mirahmedov R.R., Uraganov V.I./GNTP 4.2.4.4. (УДК 528.77 (202)). Development of satellite image decoding models - «GEO-etalon». 2002.

Briorush A.I., Development of local control and notification system for prevention of dangerous geological processes in high risk regions. 2002.

Gataullin V.Kh, Tarakin A.V., Gataullin Y.V., Lisenko S.A./GNTP-20.43 (УДК: 528.85, 528, 556.5). Development of satellite image database of the republic of Uzbekistan. 2005.