International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

March 2017 | Issue 30 | Volume 9 | Number 1 | Pages 30-36

GEOSPATIAL DATABASE IN THE NATURAL DISASTER MANAGEMENT

N.E. Samadova [1] R.B. Rustamov [2]

1. Encotec Company, Baku, Azerbaijan, nargiz_e_samadova@yahoo.com
2. Laboratory of Modern Method of Applied Electrodynamics, Institute of Physics, Azerbaijan National Academy of Science, Baku, Azerbaijan, r_rustamov@hotmail.com

Abstract- There is number of technologies applying for study of natural disaster. The fact is that it demands comprehensive approach of natural disaster monitoring and assessment of consequences. The use of traditional technologies and methods cannot fully embrace expectations in collection of required information sources for the next stage of evaluation and processing. From this point of view, it comes necessary to find and apply nontraditional methods in such aspects of problem solving related to the natural disaster investigations.

One of the common nature of natural disaster for selected geographic region is river flood. It needs to undertake number of consequences and reasons impacting damage into the environment and ecological condition of the region.

Information collected from satellite using the method of remote sensing (RS) is one of the suitable instrument for study natural disaster and its purposeful management. Advances of space technology open a wide opportunities and possibilities for preventing, preparedness and forecasting of natural disasters after required data processing stages of multi-temporal spatial data. The fact is that, in the current stage of technology applications Remote Sensing method takes one of the first place for study and monitoring natural disaster and its consequences including the disaster of floods. Undoubtedly, Remote Sensing method is the tool makes possible to collect a huge of useful quantity of information with further combine accessed from different sources, for instance topographical maps, measurement stations, purposeful developed for nominated aims or field data. It becomes obvious that Remote Sensing methods with combine of Geographic Information Systems (GIS) technology is the excellent development for disaster management processes, which can be undertaken fundamental bases for state authority decision-makers.

This paper reflects of river flood studies in Azerbaijan based on space science and technology application. The main target of use of space technology is to manage of the river flood processes. It has been stated advances and advantages of offered technology in management process as an instrument of forecasting and limitation of risk of river flood consequences.

Keywords: Space Technology, Remote Sensing, Geographical Information System, Data Collection and Space Processing, Geospatial Data.

I. INTRODUCTION

River flood is common natural disaster for almost any countries around the World. The fact is that river flood natural disaster is among the most destructive acts of nature. There are number of natural disasters existing in Azerbaijan. However, river flood is one of the main of natural disaster including landslide, earthquake and mud volcanic processes occurring in Azerbaijan. Consequence of natural disaster damages are affecting to human life as well as country industry and agriculture, which are important areas of the potential of the country.

At the same time it takes negative impact to houses and public utilities where demands to spend a big financial resources for restoration of river flood natural disaster consequences. It is important to indicated that it depends how activities related to reducing of effect of river flood can be effectively can be created to achieve expected results. For this reason information achieved by method remote sensing with further development of GIS technology makes possible duly construction of appropriate engineering facilities to minimize consequences of river flood disaster.

It demonstrates and demands to find and use of a new technology and methods for river flood studies in order to decrees of impact of such kind of natural disaster. There is no doubt that application of space technology for data collection with purpose of further decision making would be best way in achieving of expected targets on river flood natural disaster risk implementations. Obviously, it can be reached with best-developed management process, which makes necessary to collect required information based on use of advances methods for this aim.

An assessment of environmental consequences makes it necessary to integrate multidisciplinary knowledge from environmental science, ecology, geography, biology, and Earth studies. It is the field of study for evaluating the risks associated with a possible eco-environmental hazard under any existing uncertainties. Modern technologies for risk assessment include Remote Sensing and Geographic Information System; they allow scientists to predict, analyse, and evaluate the damage from disasters or

accidents and may help protect the ecosystem. Ecological risk assessment aims to provide risk management in a large scale [1, 2], which is very important for appropriate state authors in decision-making process.

II. SPACE TECHNOLOGY IN FLOOD MANAGEMENT

Obviously, space technology fids its application in a wide areas of our life. An advantage of space science and technology is to provide comprehensive, reliable accurate and multi-channel wide wave range spectral image maintenance. In fact, it makes to cover a very large square areas for investigation at the same time for collection appropriate data required for the expected time for study.

In the other hand, possibility nominated to archive wide sort of information creates excellent environment to carry out dynamic changes monitoring process, which is good outcome for definition and assessment of the status of investigated area. It relates to the flood detection, assessment and evaluation process as well. There is no doubt that today only space technology provides the basic and expected information to cover needs in appropriate time and frequency frame interval. In order to use of space science and technology is the flexible application to develop information, which reflects actual picture about the flooded areas and around linking to the flood consequences of areas, river behavior and nature of the flood before, during and after when happened of the for permanent monitoring, which is highly useful system planning, execution, and maintain required actions for flooded areas. This approach makes possible to consider watershed areas, river behavior and configurations as a source of reduce of river flood impact. It is obvious that traditional existing methods can be sufficiently cover a wide expected information for decision-makers [3, 4].

There is number of satellites nominating for diversity of purposes. The Earth observation satellites are the kind of them providing comprehensive scale of information in real time making possible for continuous monitoring starting from atmospheric measurements up to Earth surface parameters including for data related to the river flood. As it has been mentioned above Earth satellites supporting to access remote sensing data in multispectral wavelengths. This is the subject of space science and technology to develop information database in the form of map or other kind of materials based on monitoring and study for the coming out the suited data as following:

(i) identification flood inundation and construction of engineering facilities;

(ii) identification of consequences of flood damages to land cover and existing facilities etc.

(iii) study of river behavior, including silt deposits, shoals and any other segments related to nature of water basin;

(iv) assessment of the river watershed capacity and other Earth classifications in investigated area of river; and

(v) Collection existing from archive based sources hydrological and meteorological data accessed by traditional method and high technology applications.

The fact is that nowadays space information successfully uses for mapping of investigated area, which can be extended for a large-scale site and quantity of processed data. Based on such kind of information it can be delineated possible flooded areas with definition of the boundaries of flood zones [5]. It has to be indicate that space science and technology application is the suitable way on detection of changes if inundation areas with further comparison of old available for dynamic changes definitions and studies. The multi-channel data access with further processing does not limiting only the process reflected above as well as for structural measure of contamination of the consequences of river flood.

One of the main use of geostationary satellites is to provide continuous and synoptic observations of weather forecast. This type of satellites use for meteorological date collection purposes which makes available to achieve information related to the rainfall events, snowmelt run-off and monitoring of convective/frontal systems allow significantly improve the monitoring and observational system of weather studies. A measurement of variety of parameters related to the rainfall run-off analyses can be achieved by use of appropriate satellite information with available high spatial resolution. The outcomes of the processing are the area flood mapping including flood damage assessment and impact estimation.

It is important to indicate that a one more significant contribution of space technology relates to the capability of communication satellites, which creates opportunity notification in real time of relief operation of forthcoming natural disaster in particular river flood.

It is important to mention that integration foregoing information from different purposes satellites can create excellent understanding in the process of flood studies. There is always need is to assess of river flood impact, which should have a vital point in mitigation and preparedness of river flood consequences. There is no doubt that space technology plays significant place in achievement of reliable information for this purpose. The fact is that it is one more space technology applications in creating early warning systems based on the monitoring and observation with use methods of remote sensing with further GIS technology developments. It is a source to develop plans for relief, rehabilitation and post-flood assessment. An advance in the technology including in sensor and software development models has played significant place in remote sensing method use in the field of flood studies including flood management monitoring and observation.

III. OPTION OF RIVER FLOOD MANAGEMENT

A. Spatial Data Collection

A geodatabase is a store of spatial and attributive data. A geodatabase supports all kinds of data, including:

- attribute data;
- features (geographical layers);
- satellite and aerial imagery (as raster and vector data);
- land surface modelling or 3D data; and
- network systems, and field measurements.

It can also be used by ArcGIS in data processing. Storing GIS data in the geodatabase improves database management. The geodatabase is implemented as either a collection of files in a file system or as a collection of tables stored within a relational database management system.

The following are some advantages to creating a geodatabase:

- The geodatabase is integrated into the spatial system;
- All geographical data can be stored and managed centrally by a one database;
- Data input and edition are accurate and errors can be prevented, defined, and changed during the edition by use of an appropriate operation;
- Data stores in the database can be defined links with other data;
- The use of large numbers of data allows the development of good quality maps;
- Data collection can continuously be done;
- Several users can edit, input, and transfer data at the same time; and
- Dynamic changes of the process can be defined.

One of Azerbaijan's plains, the Salyan plain has been selected as the study area. It is situated on the downstream of the Kura River and is constantly exposed to flooding. The Salyan plain is located on the right side of the Kura River and occupies the area from the converging of the Kura and Akusha rivers to the Caspian Sea [6]. The plain is below the World ocean level (the maximum -12.2 m and minimum of -30.59 m). The Salyan plain is surrounded by the South-East Shirvan plain and the North Mughan plain from the north-west, the West Lankaran lowland from the south, and the Caspian Sea from the east.

As the precise boundaries of the plains in Azerbaijan have never been developed, the selected area for study is variously illustrated in different data sources. But the location of the Salyan plain with the particular existing boundary (e.g. one side with the Akusha River, the other side with the Kura River and Caspian Sea) facilitates to vectorize the boundary of the plain. Therefore, the boundary of the Salyan plain has been vectorized more accurately through the ArcGIS software application with the use of high-resolution aerial imagery. As a result, at present the plain area has been determined more accurately than previously. This is very important segment in future investigations [7].

A geographical area where the Kura River flows in the central part of the Salyan district within the Salyan plain boundary has been selected for development of the geodatabase (Figure 1). The area selected for investigation is covering approximately 24 km^2. The Kura watershed is one of Azerbaijan's most important and key point area in production agricultural products for the country. The fact is that during the last 10 years it has been observed 5 heavy excessive Kura river floods with significant consequences of damage to human and state and people properties. One of the major sources of Azerbaijan freshwater is the Kura River [8].

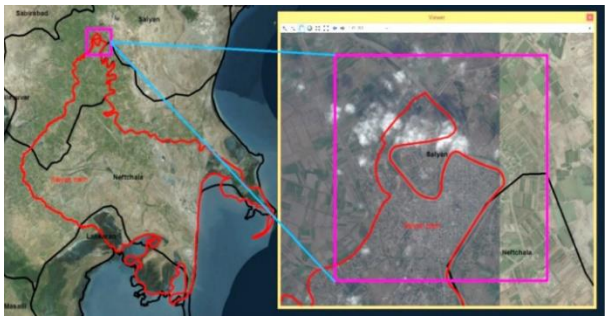

Figure 1. Geographical point of interest in the center of Salyan district

B. Geodatabase Development Flowchart Description

Satellite images, aerial imagery, archive materials, and various kinds of maps are necessary for developing digital maps, depending on the requirements of the scale or the nature of the problem. Therefore, it is necessary to collect and develop geodatabases using indicated or other relevant sources in processing stage. The existence of these materials in the pre-designing phase is vital to identify the structure of the geodatabase. But this is not an exception there is an opportunity to modify the structure by adding any new data into existing source for the best satisfaction of data-processing demands (Figure 2).

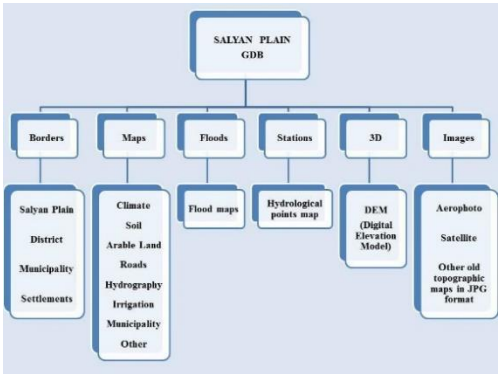

Figure 2. The structure of geodatabase development

C. Segment Measurements of the River Flood

For the time being, river flood problem takes a big place in natural disaster studies. Today we face with a big consequences of river flood impacting in the large areas of our life. For this reason, it has to be undertake structural and nonstructural measures within the framework of problem solving.

In the beginning, stage of natural disaster study it has been assured that the way to reduce river flood damages depends how effectively could be managed the rivers implemented by measurement structural condition and accessible data of floods. When it is referencing to the option of measurement of structural condition it point's out engineering construction works of facility development like execution of dams, embankments, drainage channels, etc. along of river. However, after spending large amounts of financial sources for the process of flood management, it was understood that this approach did not work properly and reflect actual condition of situation, which is important and key aspect of the whole process clarification and classification.

It is the common behavior of people who lives close to the river has to be carefully and consider consequences of river flood. Obviously, any engineering facilities has been constructed for river flood protection cannot be take place for full safely subject. However, it is not possible to protect people from damages due to the river flood even in case if there is construction of appropriate facilities for reducing of river flood consequences. It is just to minimize the scale of natural disaster impact and is not possible to maintain hundred percent of protection of river flood impact.

From this point of view, it should be not limited with a keeping the water away of the river from the area where people are leaving in order to protect the people. At the same time it has to be taken into consideration of flood plains taking vital place in protecting of human life and properties.

There is description of the flood plain, which is discovering during the river flood, takes priority place in such case. It may be dry for most part of the year. In conformity with this circumstance, it has to take into consideration of flood plain of the river. It is the main part of the process, which needed to be managed during the river flood required to reduce of the river flood consequences. At the same, time the minimization of the impact of natural disaster by river flood is nominated and accepted as non-structural approach of the process.

D. Technology Features

A developed structure consists of layers within the geodatabase (GDB). The first phase development of GDB is the structure determination of the boundary of the study area. The content of this stage contains the classification of settlements and the administrative features-territorial boundaries of municipalities. Using ArcGIS software, indicated sections have been vectorised under relevant layers within GDB (Figure 3).

Figure 3. Boundaries within Salyan plain and neighboring areas

For the next stage as a necessary segment of data, spatial data and materials undertaken for processing can be stored within the developed geodatabase by creating layers according to the structure (Figure 4).

It is highly necessary to form an attributive database of the layers after creating and vectorising the above layers, because vectorization does not reflect all the information of the selected area. For instance, contouring of the Salyan plain illustrates only location and which regions it comprises. It does not show the area's size, soil content, Earth features coordination, or the length of the boundary of Salyan plain, which are all very important and useful features of GIS development. These can be implemented by collecting, creating, and recording attribute data.

Formation of attribute data of layers within the developed geodatabase indicated above sets for each layer separately. The table below shows the structure of attribute data formation of layers within the geodatabase.

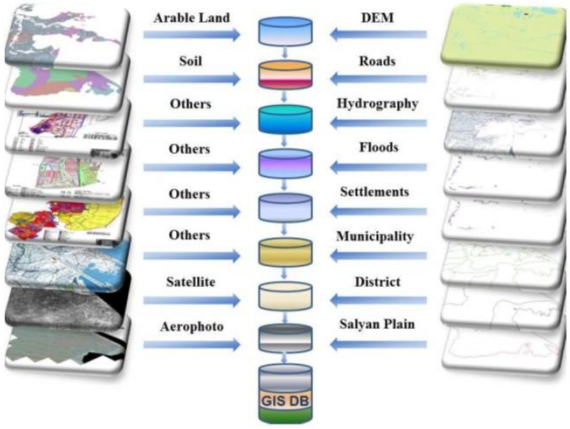

Figure 4. The sequence of data collection into GDB

IV. FEATURES MEASUREMENT FOR RIVER FLOOD MANAGEMENT/ENGINEERING ACTIVITIES

A. Structural Measures

Construction of reservoirs, embankments, drainage channels and etc. are the engineering works related to the structural measures.

B. Non-Structural Measures

It has been identified the following important non-structural measures:

The Process of Management of Flood Plain

It is desirable to reject of any consequences of any possible flood plain. It is obvious that it does not under of human power to stop the process of river flood plain. There is no any opportunity to create any obstacles for the above indication.

At the same time, there is one more important option needed to be considered that at any places in the World the population is giving efforts to select location for leave belong river to maintain food. It is the human location of flood plain which is very important for human life and in the meantime, the please with a high risk in point of natural disaster river flood view. It means that the plain is most convenient for life and danger for life protection.

Zoning of the Flood Plain

In fact, one more development in reduction of river flooding affect is the flood plain zoning, which is the instrument of classification of areas features having influence to flood impact. The next stage of the selected area is the marking/demarcating of high scale maps with use of small step of contour gaps. The further action is to display at public used areas. It would be very important and useful to consider outcomes of offered approach for the countries with a high density of population.

Regulation of the Flood Plain

The variety of executions done for zoning of flood plain zones can be managed with systematization of groups different priorities as the segments of diversity of classifications. For instance, constructions for purpose of protection of buildings and any other public or industrial entities and utilities can be undertaken as segment of flood plain needed to be regulated with aim of flood impact reductions.

The other subject like state authority buildings required to be considering standards accepted for protection of such kind of facilities can be located in zones corresponding to the frequency of river flood based on statistical date not less 50 years. The fact is that all requirements related to the safety issues of any constructions have to be defined of the protection degree depends of theirs importance and significance.

Flood Forecasting

There are number of factors, which would affected to minimization of life the loss and river flood inundation. Flood forecasting provides and plays very good and important place in for warning process. It is the source of information giving awareness about when the river is expected to rise and the scale of extent of river capacity and capability. It is necessary to mention that flood plains can be successfully used for forecasting possible river flood based on the periodic parameters and characteristics of flood.

The study of forecast of river flood based on traditional method is the old mean and problem. Quite reality, anyone who accessed to the riverbank can be visualized and in some cases an approach was that raining heavily happened many years ago and there is no any problems to consider river flood and its protection.

A good flood forecasting of river flood system helps the related to this problem solving state authorities having permanent required for flood protection measurements and observations which is creates quite good basic for further decision-making and to reduce consequences any natural disasters as whole and river flood in particular.

V. BEST WAY OF FLOOD MANAGEMENT

The fact is that analyzing different sources achieved by variety of measurements for identification of flood management and how can be their reduction achieved. For the now the question arises which method is best for river flood management in order to be able to reduce negative impacts? An obvious answer is that there is no only one method, which can be nominated as the best. Any offered for that purpose method has to be adopt according to the circumstances and needs of the expected river flood problem solving. However, there is expectations that a combination, integration and comparison of various measures achieved using different methods is the best way for river flood management. For instance, it is not enough to build of embankments along with the water reservoir or a combination of structural or any other non-structural measures and facilities are one of the aspects of reduce of river flood consequences as the way of execution of engineering construction services for river flood management case.

As the result, it might be indicated to learn and share the flood plains behaviors of the rivers. It can be used the flood plains observation and conduct measurements even in case river does not need in it. Thus, the study of flood plains definitely may be play a significant place to exceed the damage due to floods.

VI. OUTCOMES OF REMOTE SENSING AND GIS APPLICATIONS IN FLOOD MANAGEMENT

Taking into account above indication that for the time being advances in remote sensing technology and Geographic Information Systems (GIS) help to conduct monitoring in real time, early warning and quick damage assessment of consequences of river flood disasters. As far as defined that Geographic Information System is technology that can contribute managers involved for flood plain problem solving in identifying flood prone areas in their community. With development and use of GIS application can be archived in a database that would be investigated and visually displayed for analysis, processing and further use in needed aspect. By overlaying or intersecting different geographical layers, flood prone areas can be identified and targeted for mitigation or stricter floodplain management practices, which is an excellent source for decision-making. Remote Sensing effective uses for flood management in the following manner:

- comprehensive and low scale mapping that would be cover demands of the level production for hazard assessment and necessary input data to various types of hydrological models development, which could be play vital place in study dynamic changes;
- forecasting and protection of consequences of natural hazards, particularly river flood detection; and
- extension of knowledge in a big scale mapping for observation and view of the main consequences of river flood situation within a study of the river basin with the aim of identification and assessment of areas at greatest risk, prioritization of most affected river flood and the needs of immediate assistance.

Remote sensing and GIS technique and technology has taken place successfully in use of applications in the following areas river flood and its management considering main segments:

- river inundation mapping;
- plain zoning of the river flood; and
- morphological studies of the river flood.

A. Flood Inundation Mapping

There is variety of reasons make essential to develop flood and flood plain maps after river flood recedes. One of the important issue is to understand and consider prone area to assess the scale of damage caused by river flood. As far as it has discussed early remote sensing data accessed from satellite provides and reflects real picture of the flood-affected areas pointing out of the frequency of time intervals, which an excellent source for further management process. It has to be effectively to create environment in planning and organizing the process in the decision-making and operation stages.

Space science and technology achievements effectively uses in assessment of river flood consequences in the form of digital data as files of maps or any other available view of performance. Actually, this instrument not limits to perform of outcomes in the suitable form presentation as well as is very useful in study of dynamic changes and river flood behavior investigations and definitions. Flood inundation maps can be performed for:

- flood inundation reflection;
- flood affected areas identification;
- river flood impact evaluation concerned to the environment;
- assessment of scale of damage to the coastlines, forests, open space and any others;
- relief survey reflections; and
- estimation and study dynamic changes and scale of damage.

B. Flood Plain Zoning

The fact is that flood hazard zone mapping is one of the source in flood study and management process. There is no doubt that it uses as an instrument for planning of control of the non-structural flood, which is the basic for decision makers for further actions. At the same time, this approach makes possible to manage flood plain development activities. In fact, it opens opportunity to use satellite data integrated into existing hydrological data to develop flood hazard zone map for flood prone basins. Which is useful information database for further decision-making.

VII. CONCLUSIONS

This paper describes river floods are a natural phenomenon needed to be studied for a variety of reasons. It is the general problem of river flood happening in all the flood plains, which is necessary to be managed as a important factor of flooding process. An occupation of the flood plain areas of the river becomes the risk for human life, loss of properties and damages of facilities of agriculture and industrial, which demand to take significant attention to the process of management of river flood. The fact is that the problem is enough complicated and to figure out of solution is not simple.

A flood plain engagement by human is increasing population in these zones. It affects to enhancement economic, industrial and other activities which raising the risk in this area. For this reason, development of management is necessary in order to reduce losses of life, properties, as well as industrial and agriculture capacity and facilities existing in the area.

For the time being satellite remote sensing and GIS techniques have used as a powerful means to apply in a wide aspects of natural disaster management. Currently it has become very attractive to use space technology in river flood prevention, preparedness and relief management of flood disaster as a best way of theirs affect reduce management. It creates environment to consider a new approaches of methodology improvement of monitoring and observation where remote sensing GIS technology is ideally suited for various floodplain management activities to develop base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths as excellent instruments for flood management.

An outcomes of the project reported in this paper are to provide and demonstrate of assessment of current stage/condition and future flood risks in order to perform capacity and advantages of applied method in policy development and flood risk management process.

REFERENCES

[1] D. Alexander, "Natural Disasters", UCL Press Ltd., University College London, p. 632, 1993.

[2] Z. Minxia, Z. Xuan, H. Fanghua, Z. Cheng, O. Wei, W. Dan, "Ecological Risk Zone Mapping for High-Sulphur Gas Exploitation with Geographic Information System", International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII, Part B8, Beijing, China, 2008.

[3] A.K. Chakraborti, "Satellite Remote Sensing for Near-Real-Time Flood and Drought Impact Assessment-Indian Experience", Workshop on Natural Disasters and their Mitigation - A Remote Sensing & GIS Perspective, Dehradun, India, October 1999.

[4] D. Corr, "Production of DEM's from ERS-1 SAR Data", Mapping Awareness, Vol. 7, pp. 18-22, 1983.

[5] T.J. Cova, P.A. Longley, M.F. Goodchild, D.J. Maguire, D.V. Rhind, "GIS in Emergency Management", Geographical Information Systems, Management and Applications, 1999.

[6] H. Aslanov, "Ecogeographical Problems of Downstream of the Kura River", pp. 149-150, Baku, Azerbaijan, 2013.

[7] A.T. Aghayev, R.B. Rustamov, "Remote Sensing and Geographic Information System/Geodatabase in River Flood Mapping", Journal of Surveying and Mapping Engineering, Vol. 3, Issue 1, pp. 1-11, March 2015.

[8] R.B. Rustamov, S. Salahova, M. Zeynalova, S. Hasanova, "Earth Observation-Space Technology", INTECH Publishers, ISBN 979-953-307-099-46, 2012.

BIOGRAPHIES

Nargiz E. Samadova was born in Baku, Azerbaijan on May 01, 1991. She has completed her Bachelor degree at Azerbaijan State Economic University, Baku, Azerbaijan in 2013. She has a background in Faculty of International Economic Relations with specialty of economist. She has 6 years' experience at Encotec company, Baku, Azerbaijan as operating and providing engineering services in industrial areas. She is employed for HR activities mainly engaged for process assessment and measurement.

Rustam B. Rustamov was born in Ali Bayramli, Azerbaijan, on May 25, 1955. He is an independent expert on Space Science and Technology. In the past, he was in charging of the Azerbaijan National Aerospace Agency activities as an Acting Director General. He has mainly specialized in space instrumentation and remote sensing and GIS technology. He has graduated Ph.D. at the Russian Physical-Technical Institute, S. Petersburg, Russia. He was invited for the work at the European Space Agency within the Framework of the United Nations Program on Space Applications at the European Space Research and Technology Center, The Netherlands. He has appointed for the United Nations Office for Outer Space Affairs Action Teams (member, Vienna, Austria), United Nations Economical and Social Commission for Asia and the Pacific (national focal point, Thailand), International Astronautically Federation (Federation's contact, France), Resent Advances in Space Technologies International Conference Program Committee (member, Turkey). He is an author of 11 books published by the European and United States famous publishers and more than 100 scientific papers.