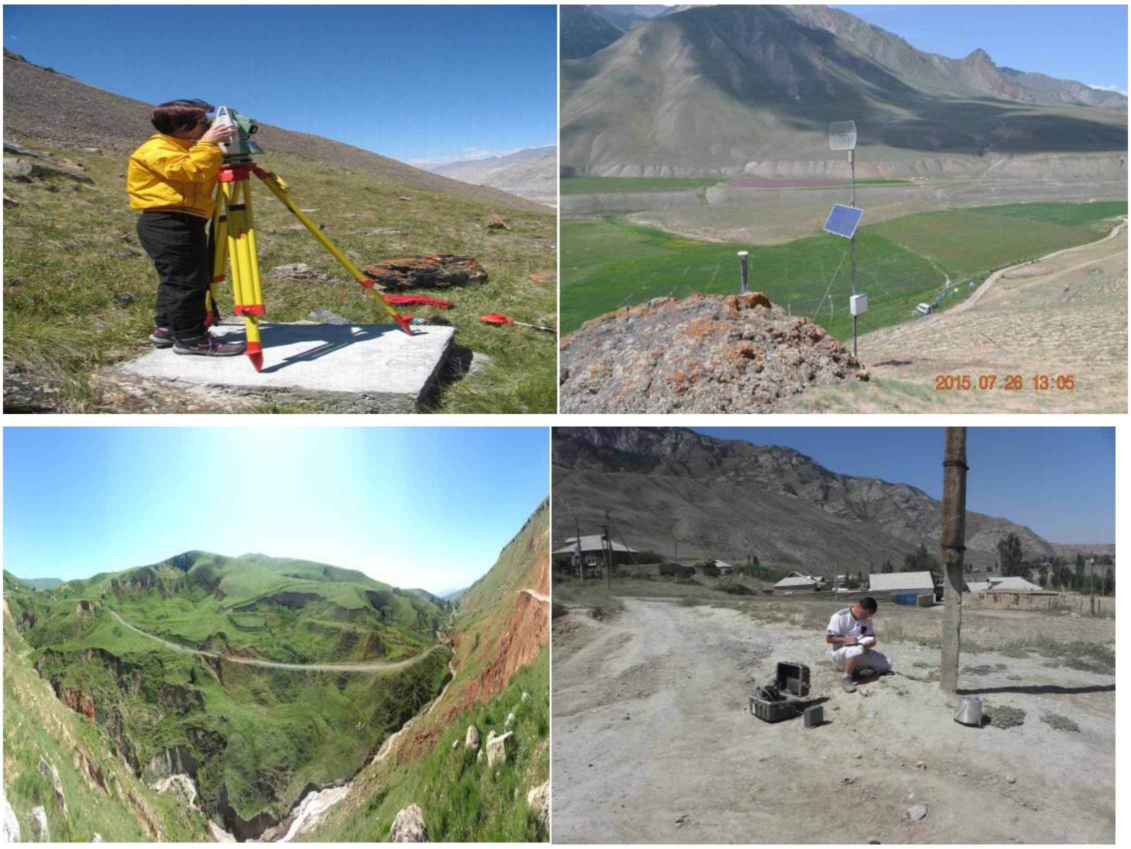
CENTRAL-ASIAN INSTITUTE FOR APPLIED GEOSCIENCES

Research & Development Programme

2017-2019



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Introduction and Overview

Central Asia (including countries as Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) is considered being a perfect natural laboratory for studying intra-continental geo-processes and global change phenomena. Known for its active water cycle, the region has significant influence on atmospheric heating processes, weather, climate and water cycle over the territory of Asia and at global scale. Active geodynamic processes connected with a continuous orogenesis induce a high seismicity in the region.

Such high dynamics of the regional geologic and atmospheric regime results in frequent occurrence of natural disasters in Central Asia as earthquakes, floods, landslides, glacial lake outburst, mudflows, avalanches and droughts, which are partly connected both with global change and geodynamic phenomena, and anthropogenic and engineering activities as well. These natural and anthropogenic hazards often result in human and economic losses, environmental problems, and have a strong negative impact on sustainable development and society welfare in Central Asia.

The assessment of risk related to any natural and anthropogenic changes that are possible to occur in Central Asia, and the development of adaptive measures of risk mitigation are of strategic importance due to the impact of such processes on the population, on the interrelationship between different countries, and on the political stability of the region. Moreover, natural processes and disasters trigger very often cascade events. Therefore, a simple single-hazard risk assessment, not considering the interrelation between the hazards, is not sufficient to develop and provide realistic scenarios to end-users and stakeholders. That is why the concept of multirisk analysis encourages the realization of research programme and activities of the institute.

Research and Development Programme

The Research and Development Programme of CAIAG for the period 2017-2019 (R&D PROG 17/19) is focused on four priority directions, which are important for Central Asian region:

1. Geodynamics and georisks;
2. Climate, water and glaciers;
3. Monitoring systems and data management;
4. Socio-economic vulnerability assessment and capacity development.

The tasks will be solved in a long-term perspective providing an advanced scientific monitoring infrastructure created in frames of international cooperation:

- Study of global and regional change processes and their effect on the environment;
- Monitoring and assessment of natural hazards, multi-risk assessment, disaster risk reduction including the development of early warning technologies;

- Applied multi-disciplinary research in the field of geodynamics and geohazards; water and land resources, including research of glaciers, rivers, reservoirs, underground water;

- Capacity building, training courses, education and public outreach.

A large part of CAIAG's work is dedicated to provide scientific services to scientific and public communities.

- Operation and long-term maintenance of monitoring networks for Earth processes, which consist of seismic, geodetic and hydrometeorological stations all over Central Asia, and the integration of these networks into global systems.

- Application of remote sensing techniques for research activities – acquisition of high-resolution space images, radar and interferometric data that extend the area covered by the monitoring networks for environmental and geological processes.

- Operation and update of the geodata platform and open access information system for Central Asia.

- Consulting services for decision-makers and public communities.

The monitoring activities are focused on the extension and operation of the data collection system in a real—time mode with the purpose to establish rapid response and early warning systems for different disasters (earthquakes, landslides, hydro-meteorological disasters, or man-made disasters). An important step in these activities will be the preparation of proposals on disaster risk reduction measures and the development of preparedness measures together with the governmental authorities and organizations in Central Asia. This will in addition involve the capacity building group of CAIAG.

All topics are of critical importance for

- the estimation of the probability of occurrence of natural and anthropogenic disasters,
- the purpose of sustainable water supply in Kyrgyzstan and in adjacent regions (Uzbekistan, Kazakhstan and the Xinjiang province)
- the development of large scale technical projects in the region, like hydroelectric power station cascades, high voltage power lines, water storage reservoirs and railway and road systems.

For the first time the research programme includes the components “Study of limnological, potamological, hydrogeological, climate processes in the Issyk-Kul lake basin” and “Social economic analysis of the vulnerability of communities in areas prone to landslide activities”. These topics will be elaborated in preparation for the establishment of an “Issyk-Kul-Observatory” in the next programme period starting 2020.

The R&D Programme for the years 17/19 is supplemented by a number of projects implemented under GFZ’s Global Change Observatory in Central Asia and the project “Earthquake Model in Central Asia” initiated by GEM.

CAIAG will implement the planned scientific programme following the Strategy of CAIAG adopted in 2012. The proposed programme references also the National Strategies of Sustainable Development of the Kyrgyz Republic 2013-2017 and the National Platform for disaster risk reduction.

THEME 1: GEODYNAMICS AND GEORISKS

Head of the development team: *Usupaev Sh.E.*

PROJECT 1.1. STUDY OF LANDSLIDE PROCESSES IN KYRGYZSTAN

Responsible executor: Usupaev Sh.E.

Co-executors: Moldobekov B.D., Ormukov Ch.A., Kalmetyeva Z.A., Abdybachaev U.A., Konokov T.

1.1.1. Project short title

Study of landslide processes using the in-situ observation and remote sensing in Kyrgyzstan.

1.1.2. Project summary

Study of landslides numbering over 6 000 in the territory of the Kyrgyz Tien Shan (around 5 000 of those are located in the southern part of the country) is a vital topic.

The CAIAG has carried out the monitoring of landslides in representative areas, such as: a) Tuiuk-Suu landslide in the area of Minkush which threatens to block the Tuiuk-Suu River and form a dammed lake able to wash out the radioactive waste tailings located upstream; b) Gulcha landslide where, after resettlement of the population from the affected area, a risk of new shifts with a potential to damage Gulcha village infrastructure still exists; c) Tectonic and Koi-Tash landslides in the area of the Mailuu-Suu town – they bear potential of forming a dammed lake and washing out radioactive tailings and waste rock dumps. In 2012-2013, study of the Tatyr landslide located in the Chon-Kurchak canyon, upstream of the left tributary of the Alamedin River, located 25 km away from Bishkek, was launched. It is supposed to carry out instrumental surveying and to use it further as a polygon. In the future it is planned to create a dynamic model of the Tatyr landslide.

1.1.3. Project objectives and methods

The project objective is the study of landslide dynamics for development of forecast and risk reduction measures.

The key methods of the study are field engineering – geological, geophysical, and seismologic measurements. Remote sensing data processing and analysis.

1.1.4. Current status and special requirements

At the previous initial research stage, the Tatyr landslide was only reconnoitered. Preliminary characteristics of the landslide body were estimated. Instrumental measurements of seismic noises and first GPS readings were taken.

The means requested are equipment (seismic stations) GPS Topcon, needed for surveying and seismic sounding of the Tatyr landslide body.

1.1.5. Work plan and required resources

Project duration is 2017-2019.

2017

- Carrying out complex geophysical studies at the landslide body and active fractures.
- Carrying out seismometric observations for assessment of dynamic conditions of a landslide (aerial survey, detailed seismic noise measurement and registration of earthquakes).

2018

- Qualitative assessment of seismic impacts and construction of a digitized map of Tatyr landslide.

2019

- Preparation of final report, creation of digitized maps with estimation of georisks;
- Publication of results.

Project 1.1.	**Number**	**Period**
	40 man-month	**2017-2019**

1.1.6. References

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PROJECT 1.2. SEISMOLOGIC RESEARCH

Responsible executor: Kalmetieva Z.A.

Co-executors: Moldobekov B.D., Orunbaev S., Ormukov Ch., Abdybachaev U.A., Jusupova K., Japarkulova A.

Detailed study related to questions of finding an interrelation between seismic and landslide activity in the Tien Shan area will be continued. Preliminary data obtained by seismological methods on a potential principal impact of the stress field to the activation of landslides show that geological data must also be used for analysis.

Since 2010, the CAIAG has an opportunity to compile the earthquake catalogue with M≥4.5 for the whole territory of Central Asia.

The third trend is dedicated to process the data on earthquakes and develop the catalogue of earthquakes of the Kyrgyzstan and Central Asia on the basis of CAREMON seismic monitoring network.

The **Project 1.2** consists of the following sections:

1.2. A. Study of the stress field of the earth crust of the Fergana Depression and its mountain framing for the purpose of investigating the relations between seismic and landslide processes (to be continued)

1.2. B. Building the earthquake catalogue with M≥4.5 in the territory of Central Asia

Project 1.2.	**Number**	**Period**
	30 man-month	**2017-2019**

PROJECT 1.2. A. STUDY OF THE EARTH CRUST STRESS FIELD FOR FERGANA DEPRESSION AND ITS MOUNTAIN FRAMING FOR THE PURPOSE OF INVESTIGATING THE RELATIONS BETWEEN SEISMIC AND LANDSLIDE PROCESSES

Responsible executor: Kalmetyeva Z.A.
Co-executors: Moldobekov B.D., Ormukov Ch., Abdybachaev U., Jusupova K.

1.2.1 Project short title

Study of the earth crust stress field for Fergana Depression

1.2.2 Project summary

Need for learning landslide processes in Kyrgyzstan is obvious – one third of annual material damage and human victims comes from landslides. It is considered that the main causes of landslide are engineering-geological conditions, physical-mechanical properties of soil covering the slope, precipitations and earthquake impact (here, we do not talk of man-caused factors). Landslides activated during serious earthquakes are known and described by researchers (Keefer, 2002; Niyazov 2009 et al.). The investigation of the precipitation impact on landslides in Kyrgyzstan and in the whole world demonstrates a 50-60% association, what suggests a significant impact of the factor. It addition, it also suggests that, apart from precipitations, there should be another yet unaccounted factor. There is little knowledge of the background seismicity effect. Our researchers (Kalmetyeva et al., 2010; Kalmetyeva and Moldobekov, 2012) show that such effect is not obvious. However, the fact demonstrating that in some cases, a simultaneous occurrence of very weak earthquakes and landslide shifting was registered which allows admitting that both events were triggered by one factor. Based on the comparative analysis of instrumental data on landslide shifting and time behavior of the direction of compression axis from the data of the earthquake origin areas, one can conclude that such factor may be a temporarily changing stress field.

Within this project, it is supposed to continue the research of the earth crust stress field and its impact to landslide activity. In the framework of the project, it is planned to carry out a more detailed research on this association, using data on more weak earthquakes, data on geology carrying out information of contemporary geodynamics, as well as to continue the fieldwork on landslide mapping.

1.2.3 Project objectives and methods

In 2017-2018 it is planned to continue the comparison of the results obtained from the study of the earth crust stress field of Fergana Depression and its mountain framing with the data available on the landslide activity.

Description of the stress field information within the project will be retrieved from processing observation data by the Fergana network. Those are data on earthquake focus mechanisms, data on dynamic parameters of the earthquakes and data on frequency content of ground in the observation points. Besides, the information of focal mechanisms retrieved for analogue stations in the territory of Kyrgyzstan will be used. The data of focal mechanisms (azimuth and angle of penetration of compression and stretching axes) will be considered along with space-time distribution of earthquake foci. It is supposed to use geological and geomorphological data more widely. Within the research the geological composition of the slope that influences its sustainability will be studied.

1.2.4 Current status and special requirements

By now the processing of materials by Fergana seismic station has been completed. The earthquake catalogue and a table of dynamic parameters of their focuses have been composed and the works on defining the frequency composition of ground in observation points are carried out.

The preliminary results on comparison of seismic and landslide activity of the studied area forces to continue more detailed research in this direction. It is supposed to carry out an analysis of geological data. The fieldwork on composing the catalogue and landslide maps of the studied area will be continued.

1.2.5 Internal and external cooperation

The project will be implemented by specialists of Department 1. In addition, we will need consultations in GFZ with Bern Schur for processing the earthquake records and with Stefano Parolai for spectral analysis and site-effect determination. At the final stage of the work, we will need consultations in the IPE of RAS (Moscow) with Rebetskiy Yu.L. on interpretation of the results obtained.

1.2.6 Work plan and required resources

2017

- Analysis of space-time distribution of weak (К<12) earthquakes
- Comparison of results on Fergana network with long-term results on seismology
- Fieldwork on landslide mapping

2018

- Analysis of space-time distribution of landslides
- Structural geological and geomorphological analysis of landslides

2019

- Comparative analysis with landslide data
- Generalization of results;

- Report preparation.

Project 1.2. A.	Number	Period
	15 man-month	**2017-2019**

1.2.7 References

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PROJECT 1.2. B: DEVELOPMENT OF THE EARTHQUAKE CATALOGUE WITH M≥4.5 IN THE TERRITORY OF CENTRAL ASIA

Responsible executor: Kalmetyeva Z.A.

Co-executors: Jusupova K.D., Japarkulova A.

1.2.1 Project short title

The earthquake catalogue of Central Asia.

1.2.2 Project summary

CAIAG carries out the research for the study of natural hazards in the territory of Kyrgyzstan (and Central Asia). Considering the high risk of seismic activity which affects occurring of natural phenomena one way or the other, creation of the catalogue of strong earthquakes in the territory of Central Asia is an essential part of the observation.

Now, the data from nearly 50 seismic stations both by the CAIAG and stations registered in FDSN in real-time mode are transferred to the CAIAG. Stable operation of this mostly virtual network is crucial for the CAIAG as an organization intended to carry out and to support the research in the sphere of geosciences in the territory of Central Asia.

1.2.3 Project objectives and methods

Since November 2010 CAIAG has created its own catalogue of earthquakes in Central Asia. Use of SeisComP software enables to localize the seismic events in real-time automatically, create bulletins of processed results and create a wave form archive. Every day the operator analyses events from the automatic catalogue within 26-57° NL and 46-87 EL coordinates. For events with epicenters, identified with various values RMS more than 2 sec., the operator manually picks the phases and identifies the epicenters again. In case of strong earthquakes within Kyrgyzstan, the operator draws an information list up, where additionally a potential intensity in the epicenter on MSK-64 scale is indicated; and information on this event, which is on the sites of different international processing centres. The information list is provided to CAIAG administration.

1.2.4 Current status and special requirements

In 2015, after a 3-year break, the KNET network data started to be transferred to the CAIAG again. The data analysis has shown that under certain circumstances it causes false events in the catalogue. Besides, as it became possible to create more weak events we can create traveltime information tables corresponding to the velocity structure of the territory of Kyrgyzstan. Considering that the latest version of the SeisComP software provides us with more broad possibilities to analyse the quality of decisions made, as well as to use various velocity models at the choice of the operator by the specialists of Department 3, this version was installed.

Installation of ACROSS network and creation of the database structure for processing and storage of these data became a new kind of the CAIAG's seismological observation. Tracking of the ACROSS network condition and the database replenishment will be concluded by the specialists of Department 3. The purposes of Department 1 include joint tracking of the data quality, as well as using these data on the issues of assessment of seismic hazard and seismic microzoning.

1.2.5 Work plan and required resources

Project duration – 2017-2019 years.

It is planned to generalize the observation materials annually when comparing to previous results.

Project 1.2. B.	**Number**	**Period**
	15 man-month	**2017-2019**

PROJECT 1.3. STUDY OF DEFORMATIONS IN FAULT ZONES BY THE EXAMPLE OF THE PAMIR-TIEN SHAN JUNCTION

Responsible executor: Zubovich A.V.

Co-executors: Ormukov Ch.A., Kalmetieva Z.A., Moldobekov B.D., Sharshebaev A., Mosienko O.I.

1.1.1. Poject short title

Study of deformations in Pamir-Alai.

1.1.2. Project summary

Over the past 130 years, in the territory of the Kyrgyz Tien Shan and its adjacent areas, there were several destructive earthquakes: Chilik in 1889 (M = 8.3), Kemin in 1911 (M = 8.2), Kemin-Chui in 1938 (M = 6.9), Chatkal 1946 (M = 7.3) Sary-Kamysh, 1970 (M = 6.8), Dzhalanash-Tyup, 1978 (M = 6.8), Darot-Korgon 1974 (M = 7.4), Batken-Isfara 1977 (M = 6.3), Markan-Suu 1978 (M = 6.8), Baysorun, 1990 (M = 6.1), Kochkor-Ata, 1992 (M = 6.3), Suusamyr, 1992 (M = 7.3), Kochkor 2006 (M = 6.3), Noora 2008 (M = 6.2).

On the basis of these statistics, it might be noted that during this short period severe earthquakes were observed in almost all the territory of Kyrgyzstan. More devastating earthquakes during this period occurred on the northern edge of the Tien-Shan orogeny in the late 19th - and early 20th century.

Alai basin extends from east to west over 150 km, and from north to south - 30-40 km. The basin is elongated along the Kyzyl-Suu River on the foot of the Alai Range as a wide valley with large quaternary and fluvio-glacial deposits. Mesozoic deposits are relatively thin (300-500 m).

Activity of Pamir and Trans-Alai range is now reflected as intra-basin deformation. The main modern tectonic element in the region is the Frontal Pamir thrust which stretches along the Trans-Alai range, deforming the above-indicated latest deposits. The deformation of strata mass (Paleogene-Neogene) shows the style and direction of the modern movements in general, both in the Alai basin and in local basins of the Tien-Shan orogeny.

It is known that the majority of earthquakes occur on the existing tectonic faults. The study of such faults by geological methods has a long history and yielded good results. With the help of these methods types of movements and their amplitude are identified. Passage of trenches along some faults identified regularity of the fact that slips occur discretely in the form of earthquakes. At the same time, the periods between seismic events, being the time of stress accumulation, are not studied sufficiently. Geological methods are not able to do it due to their accuracy limitations, and geodesic surveying gives big errors and requires considerable time due to low velocities in most of the Tien Shan faults and the presence of distributed deformations between them.

Pamir-Alai is unique in this regard. Here is a junction of two mountain systems. Pamir is approaching Tien-Shan with a significant velocity, which according to previous regional GPS studies is more than 10 mm per annum [Zubovich, 2010]. Such velocity information allows to reliably and thoroughly determine the structure of modern movements along tectonic faults and around them and, possibly, to build a model.

GPS studies carried out during recent years in this area have given good results [Zubovich etc, 2016]. With the help of GPS profile, consisting of 4 stations, it became possible to detect significant shifts between 2 observation points, equivalent to 6 mm / year and is distanced from each other for only 5 km.

During the project implementation, a detailed study will be conducted with regard to the velocity of displacements in active faults and the velocity of crust shortening on the test sites on the basis of geological and geomorphological analysis of deformed terraces and GPS measurements on the test areas of Pamir-Alai.

1.1.3. Project objectives and methods

The project objective is to study modern tectonic movements in the Pamir and Tien Shan junction area, to compare them with movements in the past geological periods (Pleistocene and Holocene) and to identify patterns of deformation processes in fault zones.

Main research methods are field studies: geological and geomorphological mapping, GPS observations using permanently operating stations and calculation of crustal shortening rate.

1.1.4. Current status and special requirements

As a test site, the Alai basin was selected, where in 2013 four GPS stations were installed in the valley of the Altyn-Dara River. In 2015, the profile has been extended by three additional stations, one of which is located at the southernmost point of Kyrgyzstan - in the Alta-Mazar site. In the same year, in the east of the Alai basin across the meridian of the Sary-Tash village another profile of 3-continuously operating stations was made. In 2016, it is planned to install additional station on the same profile. Its location will depend on the results of processing of the Alai GPS network data.

No additional equipment is required for the project. It is only necessary to keep stations in working condition.

To expand the network, portable Differential GPS equipment is required.

1.1.5. Work plan and required resources

Project duration – 2017-2019.

2017

- Geological and geomorphological mapping and profiling of active fault zones.
- Organization of automatic data collection from GPS stations. Current data processing and data quality control.

2018

- Conducting seismological and geophysical profiles of test sites to determine the geometry of faults.
- Digitization of active faults and metadata filling.
- Collection of data from GPS stations. Current data processing and data quality control. Calculation of the velocity of displacement of GPS network points. Construction of time series.

2019

- Collection of data from GPS stations. Current data processing and quality control. Calculation of the velocity of displacement of GPS network points. Construction of time series.
- Comparison of obtained data with geological and seismological data.
- Construction of a dynamic model of the Pamir-Tien Shan junction.
- Preparation of the final report and maps of probabilistic seismic hazard assessment (PSHA);
- Publication of results.

Project 1.3.	**Number**	**Period**
	26 man-month	**2017-2019**

1.1.6. References

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THEME 2: CLIMATE, WATER AND GLACIERS

Head of the development team: R. Usubaliev

Research subject: Glaciology, hydrology, climatology.

Project 2.1: Study of benchmark glaciers of Kyrgyzstan: Abramov, Golubin, Western Suyek, No.354, Petrov, No. 599, Karabatkak and Enilchek with the purpose of defining their balance, morphological and dynamic characteristics, glacier runoff and climate conditions.

Responsible executors: R. Usubaliev, A. Osmonov., E. Azisov, A. Mandychev, A. Shabunin, O. Kalashnikova, Yu. Podrezova.

2.1.1 Project short title

Study of benchmark glaciers of Kyrgyzstan

2.1.2 Project summary

Glaciers represent a significant part of the water resources of Kyrgyzstan, at present the water supplies in them estimated at about 495 km^3. In recent decades due to global warming, there has been a predominance of negative mass balance of glaciers, reduction of area and volume and respectively decrease in water reserves concentrated in them. For this reason, it is necessary to study the nature and rate of change tendencies ice in order to forecast their impact on the overall water of Central Asia. This problem is solved in the framework of this project through a detailed study of representative glaciers of Kyrgyzstan, as well as in the process of their total inventory on the satellite images.

2.1.3 Project objectives and methods:

Project objective: to determine the extent, tendency and dynamics of the glacier component of Kyrgyzstan's water resources under the influence of climatic change to forecast the change of the river flow, provision of water reserves in the reservoirs, as well as to assess the development of dangerous processes in the form of glacial lake outbursts and associated with mudflows.

Methods:

- Decoding of remote sensing data (optical multispectral, hyperspectral and radar).
- GPS-based geodesic measurement and monitoring – high-precision point by point measurement, high-precision topographical measurements by electronic tachymeter.
- Field measurements of glaciological parameters: ablation, ice temperature, ice movement rate by means of observation of ablation stakes and permanent benchmark using GPS and electronic tachymeter.
- Defining the glacier structure, its thickness, physical and mechanical parameters of ice using portable digital shallow-focus broadband seismic station.

- GIS-based space-time modeling.

Work plan and required recourses

Project duration is 2017-2019:

2017:

- Analysis of remote sensing data, factual material on glaciological, climate, hydrological conditions and parameters in the areas of Abramov, Golubin, Western Suyek, No.354, Petrov, No. 599, Karabatkak and Enilchek glaciers.
- Perform the glacier inventories in Kyrgyzstan based on decoding and space image analysis of “Landsat 8 and “Sentinel 2” satellites.
- Fieldwork on the glaciers. Hydrometric, ablation and topogeodesic measurements and the glacier’s geophysical sensing.

2018:

- Continuation of the collection and analysis of remote sensing data, glaciological, meteorological, hydrometrics data and GPS parameters.
- Perform the glacier inventories in Kyrgyzstan based on decoding and analysis of space image of “Landsat 8” and “Sentinel 2” satellites.
- Fieldwork glaciological, hydrometric and geophysical studies.
- Analysis of the data obtained and development of multifactor model of relation of the glacier system’s climatic, hydrometric and glaciological elements.

2019:

- Perform the glacier inventories in Kyrgyzstan based on decoding and analysis of space images of “Landsat 8” and “Sentinel 2” satellites.
- Development of GIS models for glaciers, defining the mass balance and their water balance constituents.
- Development of substantiation of early warning system scheme in case of outburst of Merzbacher Lake.

Required human resources:

Department 2 – 38 man-month.

Required surveys/data and equipment:

- Optical and radar space images of various types and details with various time of shooting.
- Geodesic and topographical measurement based on GPS/GLONASS receivers, electronic tachymeter (available) and geodesic GPS Topcon GB-1000 (available, additional new ones are to be purchased).
- Glaciological measurements (ablation, ice temperature), the following is required: thermal sensors with a logger.

- Geophysical glacier sensing to monitor its thickness, structure, density by means of a seismic station. The following is required: a portable mobile seismic station.

THEME 2: Limnology, hydrology, hydrogeology, climatology and glaciology

Project 2.2: Study of limnological, hydrological, hydrogeological, climatic and glaciological processes in the Issyk-Kul Basin.

Responsible executors: R. Usubaliev., A. Osmonov, E. Azisov, A. Shabunin, A. Mandychev, N. Shaidyldaeva, O. Kalashnikova, Yu. Podrezova, G. Omurova.

2.2.1 Project short title

Study of the Issyk-Kul Basin

2.2.2 Project summary

Basin of the lake Issyk-Kul is diverse with the natural landscapes, including mountain glaciers with glacier lakes, river basins with mudflows, mountain forests and semi-arid areas, the waters of the world's third lake depth, an area of about 6236 square kilometers.

Favorable climatic conditions, the presence of the warm lake water and beaches, curative mud and thermal-mineral waters, caused widespread development of tourism in the region. This raises the need for a comprehensive study of climatic, glaciological, hydrological, limnological processes using remote sensing data and field research to address environmental issues in Issyk-Kul Lake. The results of these studies will help to clarify the main causes of changes in the natural system of the Issyk-Kul lake basin under the influence of how the anthropogenic load and global climate change. They serve as a basis for predicting the trends of these changes and the development of recommendations on the rational use of the pool with minimum environmental damage, taking into account the sustainable socio-economic development of local communities, protected by natural processes monitoring of disaster risks, with a view to the conversion of the territory of Lake Issyk-Kul international tourism center in Central Asia.

2.2.3 Project objectives and methods

The project objective is to continue the comprehensive study of climatic, glaciological, hydrological, limnological processes initiated in 2014, using remote sensing data and field research to solve environmental problems in the basin of Lake Issyk-Kul, associated with water pollution and soil, depletion of water resources, with the development of dangerous anthropogenic and natural processes.

Methods:

- Analysis of remote sensing data on multispectral images, “Landsat 8”, “Sentinel 2” satellites and radar space images of “Sentinel 1A” satellite, by special satellites, usage the data of special Terra, Aqua (MODIS), Envisat and Jason 2 satellites (altimetry, temperature, precipitation).

- Analysis of time series of parameters of precipitation, air temperature, water temperature, river and groundwater discharge, lake level.
- Field topographical, limnological, hydrometrical, meteorological and glaciological measurement. The lake water temperature's measurement using thermal sensors on the area and depth. Measurement of the lake water stream and speed direction using water velocity meter device "Acoustic Digital Current Meter" (Ott ADC) (available). Groundwater sampling and laboratory analysis to determine the content of petroleum products.
- Dendrochronological analysis of climate change in the Basin of Issyk-Kul.
- Analysis of spatial distribution and alteration of time parameters based on GIS, modeling of water balance of the lake and its basin**.**

2.2.4 Work plan and the required resources

Project duration is 2017-2019.

2017:

- Collection and analysis of remote sensing data, factual data on limnological, hydrometric, hydrogeological, climatic and glaciological parameters of Issyk-Kul Lake and its basin;
- Analysis of data retrieved using different data processing methods, climatic change analysis and related limnological, hydrological, hydrogeological and glaciological changes in the region and definition of anthropogenic load on the lake and its basin;
- Field studies on the shores of Issyk-Kul Lake, measurement of water temperature, groundwater sampling at the oil pollution site.

2018:

- Continuation of fieldwork for new hydrometric measurement, environmental, GPS parameters
- Acquisition of new factual data using satellite image decoding and comparing the decoding results for different time series

2019:

- Study of the climate change impact and the growth of anthropogenic load on ecological situation in the basin.
- Development of complex GIS model of climatic, hydrogeological, hydrological and limnological systems in the basin of Issyk-Kul and digital map constructions in GIS.

Required human resources**:**

Department 2 – 70 man-month.

Required surveys/data and equipment**:**

- Optical and radar remote sensing data (satellite images of different types and granularity at different shooting time).
- Meteorological parameters: temperature and precipitation for the meteorological

network stations. Long-term data on the groundwater level mode.

- Data on hydrometric observations: river gauging network costs. Data on the current velocity in the lake. Hydrological observation data: river discharge by hydrological station network. Data on flow rate in the lake. Determination of concentration of oil products in groundwater.
- Observations of the level of Issyk-Kul Lake.
- Geodetic ground surveys: geodesic measuring the level of the lake using GPS Topcon GB-1000 and electronic tachymeter (available).
- Equipment for dendrochronological study.

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THEME 3: "MONITORING SYSTEMS, IT-INFRASTRUCTURE AND DATA MANAGEMENT"
Head of the development team: A.V Zubovich

Project 3.1: Development and technical maintenance of CAIAG's monitoring systems

Responsible executors: A.E. Shakirov, A.K Sharshebaev.

3.1.1 Project short title

Monitoring system.

3.1.2 Project summary

Central Asia is a region known by its sharply continental climate, high mountains with numerous rivers and dry deserts. High tectonic activity leads to devastating earthquakes with catastrophic consequences. Landslides, avalanches, mudslides, floods, droughts are an integral part of this region. As a result of these processes, people are affected and the infrastructure is damaged. Therefore creation of the instrument networks which would monitor the hazards in close to real time mode is vital for the states located in this region. This project aims to maintain and develop the seismic, hydrometeorological and GNSS monitoring systems, which were established in previous years. The system includes:

- Network of monitoring stations
- Data transmission subsystem
- Data acquisition and processing subsystem

Network of monitoring stations consists of stations with different purposes and configurations. The common feature of all stations is that they are provided with an autonomous power supply system, the station control system and the data transmission equipment. A set of sensors is changed depending on installation conditions.

Data transmission subsystem is organized depending on the conditions under which the stations are located. It is either a VSAT satellite system with reserve Iridium communication system, if the station is located in remote mountainous areas, or GSM communication, if it is located in an area covered by one of mobile operators, or Internet, if a station is installed in the village, covered by Internet, or communication by radio channels located near the stations equipped with VSAT.

CAIAG's subsystem for information collection and processing is equipped with contemporary equipment consisting of a set of servers, storage arrays and software system for equipment monitoring and data collection, processing and storage.

3.1.3 Project objectives and methods

The project's objective is to develop and support the CAIAG's monitoring network. The project will include:

- Improvement of existing stations.
- Inclusion in the system of monitoring stations, installed on other projects.
- Development of hardware, software, organizational components for data collection, storage and processing.
- Technical maintenance of the stations (scheduled and unscheduled).

Experience in the monitoring system development has shown that the existing stations require maintenance and need to be modernized.

Implementation of various projects, if it includes creation of new stations or observation networks, gives an opportunity to increase the CAIAG's monitoring system. The problem may arise, if there are discrepancies of data formats and interfaces of new stations with the existing system. This project component is aimed to create conditions that allow integrating the new stations into the CAIAG's monitoring system, suggesting development of software tools, re-equipping with necessary equipment and implementation of various organizational measures.

This project contributes to achieve the objectives of "the CAIAG development strategy".

3.1.4 Current status

Currently, the CAIAG monitoring system includes:

- 15 GNSS stations:
  - 1 station with "Allan Osborne BENCHMARK ACT" receiver and with "Vaisala PTU 200" (BIS2) meteorological station on the CAIAG's roof;
  - 4 stations with Topcon GB-1000 receivers and GSM communication (KRGT, KRBK, TKUM, ARSL);
  - 3 main stations in the Alai Valley (ALAI, ALA6, SARY) with Septentrio NV AsteRx2e HDC receivers, including VSAT communications and Vaisala WXT520 meteorological stations;
  - 7 slave stations in the Alai Valley (ALA1, ALA2, ALA3, ALA4, ALA5, SAR1 and SAR2) with Septentrio NV AsteRx2e HDC receivers, transmitting data by radio to the main stations;
  - 1 station (ICED), installed at the Enylchek Glacier's ice dam near Merzbacher Lake.
  - 1 smart station, which includes the Vaisala WXT520 meteorological station, Topcon GB-1000 GNSS receiver and VSAT satellite terminal (ENEL)
  - 1 smart station, which includes STS-2 broadband seismic station and the entire equipment for the CAWa project stations.

- 12 hydrometeorological ROMP stations (ABRA, ASAI, AYVA, GOLU, HM01, KABU, KEKI, KMBL, MADK, MTAL, MRZ1, TARA), including temperature, air humidity, atmospheric pressure, wind speed and direction, liquid precipitation, temperature and soil moisture, solar radiation sensors, and also the GPS receiver, from which:
  - 3 stations (ASAI, MRZ1, TARA) include STS-2 seismometers;
  - 3 stations (ABRA, GOLU, MRZ1) are equipped with a pair of cameras each;
  - 4 stations (GOLU, HM01, KMBL, METAL) are re-equipped with SPA snow meters;
  - 2 stations (KEKI, METAL) include river water discharge sensors.
- ACROSS network's 12 strong motion stations established by the MES's fire brigades (JANJ, CHAK, KKOL, AKSU, KZSU, KAJS, TAMCH, KCHK, KAYN, TALS, TKMK, ANAN).
- SOSEWIN network stations, installed in 8 buildings and in a well in Bishkek (CAIAG, BIVA, INTUIT, KIS, KGUSTA, TALL BULDING, IVANYCYNA, EMERGENCY, PRIVATE HOUSE).
- Dust station.

Location of these stations is shown in Figure 3.1.

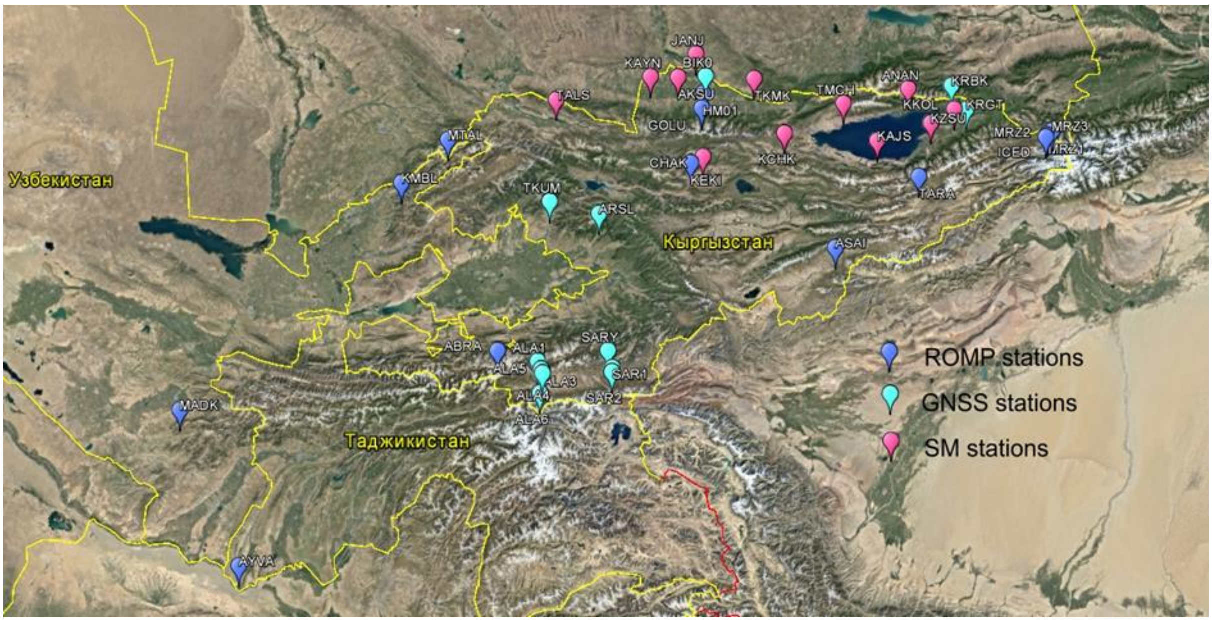

Figure 3.1. The CAIAG's monitoring stations placement scheme.

3.1.5 Internal and external cooperation

The project is carried out by specialists of Department 3 in cooperation with the various departments of GFZ. In some cases, specialists of Departments 1, 2 and 4 can be take part. There will be a continuation of cooperation with specialists from various organizations of Kyrgyzstan and other Central Asian countries, with European, Asian and American scientists.

3.1.6 Work plan and required resources.

2017 - 68 man-month

2018 - 68 man-month

2019 - 68 man-month

3.1.7 References

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PROJECT 3.2. DEVELOPMENT AND SUPPORT OF THE CAIAG'S INFORMATION SYSTEMS

Responsible executors: Zhantaev M.M., Mandychev D.A.

3.2.1. Project short title:

Development of software and information system "Data Platform".

3.2.2. Project summary

In recent years, the CAIAG performed and still performs a number of projects, as a result of which the information systems based on web interfaces and databases are created. Some of them are developed for third-party organizations and do not require support at the completion of projects. However, for systems designed for the CAIAG's needs, they require support and development. Among them:

Data Platform. Based on Open Source software of GeoNode agent, which is continuously developing and has good prospects. It is assumed that the spatial data available in the CAIAG or prepared as a result of fulfillment of any projects should be entered in the platform in line with the Institute's access policy and related projects. Geodata search mechanisms, the use of OGC services and metadata catalogs will be tweaked. On the basis of map layers available, style graphics editor GeoExplorer as an internal GIS client the multilayered interactive maps that can be embedded in a web page and printed out in PDF-format will be created. Teamwork of users to review, assess and comment on the data, the creation of user groups, accounting activities, announcements and notifications will be worked out. A multi-level ranking of access to data in compliance with the requirements of their authors will be also worked out.

Sensory data storage system (SDSS). It is storage of data transferred from the monitoring station sensors. The system has been developed in the CAIAG within the framework of CAWa project. It enables inputting, editing and storage the sensory data in the database, editing, storage and viewing some of the metadata, building a time series in graphic form, the output data in tabular form in Excel format and unlimited multilingualism. Using the SDSS has shown its universal character – except the data obtained directly from the sensors, the system can store and process the data, for example, automatically loaded in the SDSS satellite altimetry information on water levels in the reservoirs of Central Asia, the receipt of which is organized in GFZ section 1.2 (T. Schöne).

This project envisages the development of SDSS. It is planned:

- Rearrangement of existing features of SDSS on the webpages, as well as addition of new functions in order to obtain more intuitivity using the system.
- Improvement of meta-information system in accordance with generally accepted standards.
- Creation of a set of web-services, including receiving of data and metadata on the request, input and edit of metadata.

- Development of a universal custom retriever for independent input data to SDSS by external users.
- Development of a detailed description of the system in the form of user manuals and interactive prompts.
- Other improvements, the need for which arises constantly.

Seismological databases

- SeisComp3 database. The project provides its technical support and update, along with SeisComp3 programs for Department 3, 1, and the MES. Preparation of solution and its implementation to display the seismic situation in the region on a larger screen in the CAIAG's hallway for general viewing.

- Strong motion database. It has been developed by the National Institute of Geophysics and Volcanology (NIGV), Italy, and set within the framework of ACROSS project. The database contains data for the territory of Central Asia, derived both from the global sources, and the CAIAG network stations. In the forthcoming project period, its current support and development together with INGV and GFZ are assumed.

GPS database. Serves to store information of the GPS data received from the CAIAG's monitoring stations and external sources around the world. The database enables to organize the GPS data accumulation and processing automatically and to control the incoming information.

While there is no program shell around the GPS-data PostgreSQL database management system, which allows simplifying work with data. During the project execution time, programs to organize Web-interface for data receipt control and process of their processing and display of results must be designed.

3.2.3. Project objectives and results

The project objective is development and support of information systems and databases used in the CAIAG. Considerable time should be given to their wide application both within the institute and outside of it. In order to do it, various kinds of training and release of directory information will be widely used. Only Open Source products will be used continuously as software.

All information systems developed in the CAIAG and dealing with the geospatial data should be based on OGC standards and be able to direct integration into the national infrastructure of spatial data in Kyrgyzstan. If this is not contrary to the requirements of projects and data authors, the data access policy should be opened.

3.2.4. Current status

Data Platform. The beta-version of GeoNode content management system v2.4c11 has been installed and debugged. The trial operation has revealed a number of shortcomings on the part of style management, metadata support and group permissions system for users. Resulting from developers of announcements in GeoNode's next stable version, on which the

DP should be based, these shortcomings should be eliminated and new features added. Now most of the spatial data is distributed in the CAIAG user computers. There must be work to collect, organize and bring them to a common format and standard for subsequent upload to the DP.

SDSS. In the work we use version V. 1.3. About 150 million measurement data on 113 measured parameters from 54 observations stations objects have been accumulated in the database. The system is translated into three languages: Russian, English and German; a free access to the data through web-interface was organized for all comers.

Seismic databases. Database Seiscomp 3, built on MySQL database management system, operates normally, serving the seismic events automatic processing system. Strong motion database, also built on MySQL, is running in test mode, starting to accumulate information.

GPS database is built on PostgreSQL and includes 11 tables.

3.2.5. Internal and external cooperation

The project is carried out by specialists of Department 3 in cooperation with GFZ (sections 1.2 and 7.1) and NIGV. At the stage of data collection the departments of other institutions, organizations and agencies of the Kyrgyz Republic will be involved.

3.2.6. Work plan and required resources

Work plan:

No.	Name of works	Resources	2017	2018	2019
1	Data Platform development and support	24 m/m.	+	+	+
2	SDSS development and support	20 m/m.	+	+	+
3	Seismological database development and support	24 m/m.	+	+	+
4	GPS database development and support	14 m/m.	+	+	+

3.2.7. References

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PROJECT 3.3: CAIAG'S IT-INFRASTRUCTURE DEVELOPMENT AND SUPPORT

Responsible executors: S.Barkalov, A.Ismailov.

3.3.1 Project short title

IT-infrastructure development.

3.3.2 Project summary

The Institute's needs in information and computing resources cannot be solved by user computers only. Many tasks require server hardware. These are servers and storages for maintenance and network administration tasks, storage and exchange with user files, database placement, data collection system by monitoring stations, routine tasks for processing large data arrays in the automatic mode, FTP and Web sites and others. This enumeration shows that all of them use considerable resources of IT infrastructure and, therefore, it needs to be maintained, planned and developed. It is necessary to make solutions optimizing the use of computing equipment. It is necessary to be prepared to implementation of scientific and technical tasks, which will arise in the future and certainly require a significant increase of reliability of the IT infrastructure used.

3.3.3 Project objectives and methods

This project objective is to provide high availability of the CAIAG's IT-infrastructure to perform the Institute's scientific tasks. The background shows that the IT equipment, which consists of setup, configuration and testing software, must be prepared deliberately**.** Within the framework of the project, it is planned to improve the existing systems, to implement the non-failure operation scheme, to study the user experience of contemporary cloud technologies and develop proposals for their use in CAIAG. The project will include:

- **Virtualization server clustering and storage system virtualization.** It is necessary to move to a new level of quality of use of virtualization systems by reducing downtime for maintenance, the use of duplicate equipment and increase productivity**.** A possible and effective solution is virtualization server clustering and virtualization system storage. It is also necessary to work on selection and implementation of solutions to improve the interaction between the user and virtualization systems, monitoring organization and accumulation of statistics on the work of virtual hosts
- **Study of experience and preparing decisions on deployment of cloud-based systems.** Solving standard tasks on file storage organization or archives for different projects and research groups, we have to be aware of necessity to implement systems, comfortable and convenient for the administration, combining different type storages into a single scalable structure called a cloud storage system. The project provides opportunities for cloud system learning and experience by their implementation, as well as careful thinking of their use in the Institute's infrastructure.

- **Preparation of solutions and selection of a platform for creation of a single portal system, an employee's online window, as well as terminal systems for the CAIAG's needs.** It is planned to carry out organization works on the Web- oriented platform with a set of functions that help to provide a remote work place for a scientific researcher.
- **2nd server room organization, IT infrastructure electricity modernization.** Due to the need to expand the server space need to work out the requirements to a special room for accommodation of communication and server equipment**.** The room located on the semi-basement floor of the CAIAG's second building. In the design and implementation, a special focus should be paid to electricity, cooling and communications. In consequence of implementation this part of project will be a second server room, ready to allocate into the necessary computing resources. It is planned to transfer some of the equipment from the first room.
- **Technical support includes:**

  - Maintenance of user workstations and office equipment.
  - Maintenance of server and communication equipment.
  - Maintenance of equipment (scheduled and unscheduled work)

3.3.4 Current status

Currently, the CAIAG's IT-infrastructure includes several components and equipment, listed in the appendix.

3.3.5 Internal and external cooperation

The project is carried out by the specialists of Department 3.

3.3.6. Work plan and required resources

- Planning, design, operation analysis, implementation and administration of the IT infrastructure's server components.
  2017 – 14 man-month, 2018 – 14 man-month, 2019 – 14 man-month.
- Planning, implementation and administration of customer systems and maintenance of office equipment.
  2017 – 12 man-month, 2018 – 12 man-month, 2019 – 12 man-month.

Table 3.3.2. Required equipment

No.	Name	Equipment
1	Communication infrastructure	Additional switch-boards for the 2nd server room, equipping with optical Packards and SFP modules to increase capacity.
		Two new routers to create a duplicate mode and hardening
2	Computers and laptops	New computers, defective parts for replacement.
3	Virtualization infrastructure	Discs for replacement and addition
		Additional memory
		Cooling components
4	Engineering infrastructure	Means for switching the input source. Power Distribution Units (PDUs).
		The second air conditioner for load balancing and fault tolerance
		Module ventilation mode, running on back-up power system.
		Temperature sensors and alarms
5	Scientific equipment	The acquisition of the projector for replacement. Equipment for Skype conferences
6	Office equipment	Two new laser network printers for scientific researchers
7	Equipment for the new server room	Cases, servers, switch-boards, cooling systems. The list is defined at one of stages of the project.

3.3.7 References

Electronic documentation:
http://redmine.caiag.kg/
https://docs.citrix.com/
https://docs.oracle.com/
http://www.fujitsu.com/ca/en/products/computing/storage/
http://wiki.nas4free.org/doku.php
https://www.freebsd.org/doc/handbook/
http://docs.openstack.org/ops-guide/index.html
http://wiki.mikrotik.com/wiki/Manual:TOC
https://habrahabr.ru
www.vmware.com/ru/virtualization/how-it-works
http://citforum.ru/nets/storage/virtualization

THEME 4: CAPACITY DEVELOPMENT AND SCIENTIFIC COOPERATION

Responsible executors: Dr, Prof. T.S.Bobushev
Executors: Kylychbaev E.G., junior researcher, Rakhmatov U.K., junior Researcher

Project 4.1: STUDY OF DISASTER RISK: METHODOLOGY SOCIO-ECONOMIC VULNERABILITY ASSESSMENT AND ADAPTATION OF RURAL COMMUNITIES

(The case of the Issyk-Kul oblast, Kyrgyz Republic)

4.1.1 Short title of the project - SEARC

Socio-economic assessment of adaptation of rural communities in a changing environment**.**

4.1.2 Project summary

The development of rural communities, under conditions of different livelihoods, conflicts and diseases, changing geography and demography in the countryside and the environment, have brought significant changes in the development of rural areas. Rural communities are still facing with the traditional development issues such as poverty and illiteracy, which significantly aggravate due to the increase of risks related to disasters, as well as to climate change. There is a need to reorient rural area development policies and strategies in order to use realistic approaches, not only to withstand the changing problems of rural development.

It is known that the preparedness and the response of individuals, groups of people or communities, socio-economic and natural systems to changes in their environment is called adaptation. Such changes can be induced by various causes and processes. Among these processes, by right, there is global climate change on our planet. Emissions of greenhouse gases due to human activity and other geophysical processes over the past century led to a sharp climate warming. Humanity has never experienced the warming of such scale, and its physical effects may limit the opportunities for development, especially in agriculture, the most important production sector for rural communities in mountainous areas. This adaptation process is quite often in practice, can be combined with the risks that should be considered as opportunities for development. However, many people, especially the poor, are often reluctant to take risks for fear of possible negative consequences. Failure to properly manage the risks leads to crises and missed opportunities. Achievements made thanks to great efforts in the field of rural development in the previous decades in our country must be protected, increasing resistance to risk, because without this it is impossible to achieve economic well-being of people, and this truth does not depend on what we have to deal with: a natural disaster, financial crisis, the surge of crime in society or serious illness of the main breadwinner of the household. It is never possible to eliminate the risk. However, the people, institutions and organizations within local communities can build the risk resistance capacity using a balanced approach that includes structural policy measures, preventive measures at the level of rural communities: education, training and effective regulations. It is necessary to keep in mind that avoiding any risk may be the most risky decision.

4.1.3 Project objectives and methods

The mere detection of natural hazards (risks), despite the importance of their study, is not enough. It is also required to identify and develop compromise solutions to overcome obstacles to risk management, ranking them in order of priority and management by individuals, rural communities, and government institutions. In this regard, the project will focus on studying the impact of climate change on natural processes, agriculture and rural communities. Special attention will be paid to assessing the impact of climate change on vulnerable groups and on agriculture in the framework of rural communities through:

- the use of interviewing and other tools to collect and analyze knowledge about:

a) The experience of vulnerable groups (women, youth, the disadvantaged, etc.) in relation to climate change;

b) The possible future vulnerability and the risk of climate change consequences;

c) The institutional capacity of local communities to adapt to natural hazards.

These interviews and reviews will help us to determine the measures to prevent or reduce the impact of the expected vulnerabilities and risks. In addition to this, it will help us to identify new ways **to build adaptation capacity of communities**. At the end of the study, the analysis of socio-economic data and impact will be conducted, as it will provide a better picture of the context in which climate change will have its own impact. We begin our impact analysis with an analysis of natural (e.g. land, water) and socio-economic conditions (population, transportation infrastructure, buildings, etc.) in the current situation. To collect empirical materials, a single technique of sociological research will be used which includes qualitative and quantitative methods: 1) a massive survey of the population in the study villages; 2) standardized expert interviews of rural intellectuals and the local elite; 3) selective non-formalized interviews of experts and rural intellectuals; 4) collection of documents from official authorities (statistical data, plans, development programs, etc.). In the period of research preparation and implementation, satellite images and other cartographic materials will be studied, as well as materials of local periodicals reflecting the main problems of socio-economic development in the surveyed settlements.

4.1.4 Current status

The study of the issues related to assessment of vulnerability, adaptation of rural communities will be carried out within the period of 2017-2019 on the territory of Zhargylchak, and Kumbel ail okmotu, in the Issyk-Kul and Jeti-Oguz rayon (district), Issyk-Kul oblast (region).

4.1.5 External and internal cooperation

To develop specific adaptation models, the cumulative impact and study of the following factors are important:
- Proximity or remoteness from urban centers;
- Availability of natural and geographical resources;
- Ethnic specificity, etc.

as well as internal factors: the size of the settlement, its administrative status, economic structure of rural communities (multi-functionality or single-industry specialization), etc. The study will cover the administrative, organizational, economic and financial instruments, special instruments for regulation of local development, identification of ways of increasing decentralized sources for funding community development. It will also include development of the system transfers provided to the regions and communities lagging behind in socio-economic development, as well as the formation of special regulatory instruments.

The project will be executed in collaboration with Departments 1 and 2.

4.1.6 Work plan and required resource

Duration of the project: Phase 1 - 2017, Phase 2 – 2018, Phase 3- 2019.
It offers a preliminary plan, which will be detailed after the expert review and the formation of researchers' team.

Phase 1 - analysis of the impact of climate change on vulnerable groups.

The objectives of the project on 1 stage 2017 includes:

In order to determine the level of climate change affect vulnerable groups (women, etc.), we will try to address the following questions:

1. **How are communities in rural areas, especially those dependent on agriculture, threatened due to decrease the availability of water / energy?** For the water sector,

this creates risks in terms of long-term viability of systems and a number of treatment units.

2. **How is irrigation ensured because of climate change?** Water management in times of deficits is more complex and demanding. More accurate account of water should be kept and, to maintain it, water measurements will be requested.
3. **How to increase the demand for water?** A good indicator is the increase of the proportion of water used for irrigated crop production. Tensions over water distribution will become more serious, when the supply of water will be less.
4. **What will be the effect of reduction of crop production and provision of food security because of changes in access to water and energy?** Vulnerable communities face with uncertainty and deterioration of the environment, water resources and food security, which could have serious consequences in a very short time.
5. **How will the increase of water and fuel tariffs affect vulnerable groups?** Climate change will have an impact on the cost of electricity and water. This increase may be inaccessible to vulnerable groups. The growth of power outages because of the increase in demand should also be evaluated.

Bobushev T.S., Rakhmatov U.K., and Kylychbaev E.G. would be involved on the study at the first stage of the research. From the total research time, 2 weeks of the year will be devoted to the study in the field. In view of the time spent on a project, in all will be spent time by each employee - 12 man-month, or totally 36 man-month (3 x 12 = 36 man-month).

Phase 2 - analysis of the impact of climate change on agriculture in the framework of rural communities.

During the second phase of the study, the analysis of the impact of climate change on agriculture in the framework of rural communities will be made.

1. Dynamics of changes in surface air temperature (agricultural land – by area, by time - 10, 25, 35 yrs.).
2. Dynamics of precipitation – by area, time -10, 25, 35yrs.).
3. Growth \ Reduction of crop yields per hectare (a trend, losses in %)
4. Changes in the yield of cereals, potatoes and vegetables (by area and time)
5. Changes in the income received from the agricultural products (trends, losses in %))
6. Changes in the volume agricultural production (trends, losses in %). What is the structure of agricultural products – crop and livestock products - by the production volume and cost (earned revenue).
7. Changes in the value of land - in general and agricultural (trend). Who regulates the prices of land, level of sales and purchases?
8. Changes in agricultural product prices (tendency, losses in %). What markets are used?
9. Changes in the growth of demand for food and food production growth (trend). Are local people familiar with new technologies, if so, with what and do they trust them.
10. What is the population growth and the level of family income?

1. The supply and demand for agricultural products (a balance, or something else or other).
2. The volume of agricultural production and the land quality, climate change and the amount of fertilizer applied.
3. Influence of temperature and rainfall on agricultural productivity through the analysis of the relationship between the land price and the climate (agriculture productivity increases as the temperature changes from cold to warm, and then declines when it changes from warm to hot, in the mountainous areas in elevation).

Bobushev T.S., Rakhmatov U.K., and Kylychbaev E.G. would be involved on the study at the first stage of the research. From the total research time, 2 weeks of the year will be devoted to the study in the field. In view of the time spent on a project, in all will be spent time by each employee - 12 man-month, or totally 36 man-month (3 x 12 = 36 man-month)

Phase 3 - Development of a system of socio-economic indicators and vulnerability maps areas of research.

The objectives of the project at the stage 3 in 2019 included:
1. Develop a system of socio-economic indicators of the territories of rural communities,
2. Systematization and assessment of thematic maps for the making maps of vulnerability of rural communities of the territory.
3. Mapping the vulnerability of the study area.
4. Preparation of Final Report.

Bobushev T.S., Rakhmatov U.K., Kylychbaev E.G. would be involved in the research on this final stage of the research . From the total time of research, one (1) week will be devoted to the study in the field. Most of the time is devoted to creating of the Maps of vulnerabilities of the study area. In view of the time spent on a project, in all will be spent time by each employee - 12 man-month, or totally 36 man-month (3 x 12 = 36 man-month).

Required resources.

- An increase in the department staff - up to 5 units (currently employees 3 people).
- Providing access to cartographic sources (thematic maps).

4.1.7 References

1. Atlas of Natural Hazards and Risks of Georgia. 2012, pp. 105.
2. Climate-Smart Agriculture. Sourcebook. Food and agriculture organization of the united nations, 2013
3. William R.Clyne. Global warming and agriculture. Finance and Development. 2008
4. Guidelines on water resources and adaptation to climate change. European economic commission. New-York-Geneva, 2009.

5. Risks and opportunities. Risk management for development. WB, 2013.
6. I.A.Makarov. Global climate change as a challenge for world economy and economic science. Economic magazine of Higher Economics School, 2013.
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9. Migration and global environment changes. Challenges and opportunities in future. Final project report. 2011.
10. Modelling of the economic development impact on the environment. Petrozavodsk, 2009.
11. Robert Putnam. Therefore, the democracy could work. Civil traditions in modern Italy. M., 1996.

Appendix 1

List of IT components and equipment

No.	Name	Model	Amount	Comments
1	**Communication infrastructure**			
1.1	Ethernet switch-boards			
1.1.1	Switch-board for server case No.2	HP-2910al-48G	1	Setting change, control
1.1.2	Switch-board of 28 series for user connections	HP J4903A ProCurve Switch 2824	3	Setting change, control
1.2	Routers			
1.2.1	Router 99 (Firewall, server routers, servers, inter-segment bridge, routing of virtual private networks, dynamic allocation of server IP- address and registration)	Router-board 1000	1	Setting change, control
1.2.2	Router 168 (Firewall, router for user devices, balancing, backup internet access)	Virtual host		Setting change, control
2	**Computers and laptops for researchers**			
2.1	Handheld mobile computers		25	Service
2.2	Stationary desktop computers		70	Service
3	**Virtualization infrastructure**			
3.1	Virtualization servers			
3.1.1	Xen Cloud Platform 1.6 xenserver56	DELL R820	1	Adding disks
3.1.2	Xenserver141	SunFire x4600	1	Replacing drives, controller replacement
3.1.3	xenserver-across_202	Supermicro	1	Service
3.2	Storage infrastructure			
3.2.1	Drive array to 12 drives	Storagetek 2540	1	Replacement with fast disks
3.2.2	Drive array to 24 drives	Fujitsu DX80	1	Repair of 2-Disk
3.2.3	Drive array to 12 drives	Storagetek 3511	1	It is planned to install 7 drives
3.2.4	Server reserve coping	Sunfire v240	1	Replacement of cooling components
3.2.5	NAS226 Project network storage for server farm. The file server to store scientific data sets	Rx200s2	1	Additional memory installing
3.3	Standard servers			
3.3.1	Regional server for satellite ground stations WINDS	Fujitsu rx300s5	1	Transfer the virtual environment

3.3.2	Server 175 for Databases	Fujitsu rx300s4	1	Memory increasing, preparing for a new purpose
3.4	**Infrastructure servers**			
3.4.1	Postal system	hp dx2200	1	System unit replacement due to wear-off
4	**Engineering infrastructure**			
4.1	Uninterruptible power systems			
4.1.1	Uninterruptible power supply source for the server room, the service only server and communication equipment.	UPS MGE comet 11 KWA	1	Acquisition batteries
4.1.2	Uninterruptible power supply source for the server room and the user computers	UPS inform 360 PPS	1	Acquisition of new fans and their replacement
4.2	Ventilation, cooling and air-conditioning			
4.2.1	Air conditioning in the server	Power, name	1	Cleaning, repair
4.2.2	Air conditioning in the room for UPS	Power, name	1	Cleaning, repair
4.2.3	Fire automatic fire extinguishing system. In the server room	Gas	1	Gas, replacing