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GUIDELINES

on regional disaster risk assessment for the territory of Tajikistan

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Application domain

This methodology is designed for use by governmental, non-governmental and international organizations operating in the area of natural risk assessment and analysis at the regional level, disaster prevention and mitigation in the Republic of Tajikistan and also development planning of territories. This document does not determine the frequency and need for risk analysis as well as specific levels and criteria of acceptable risk. Specific requirements as to the level and criteria of acceptable risk can be established, as appropriate, by government authorities of the Republic of Tajikistan.

PREFACE

Tajikistan is one of the countries with the highest exposure to natural disasters. Natural disasters have disastrous effects on communities resulting in loss of human lives and destroyed infrastructure hampering further socio-economic development. With a view to the above, implementation of disaster risk assessments appears to be very relevant today. There are a number of methodologies currently used for disaster risk assessment in Tajikistan (MECO, FOCUS). These were developed by international organizations with the mandate in disaster risk reduction. The key distinction of the applied methodologies is their focus on (rapid) disaster risk assessment and risk reduction at the level of individual communities and jamoats. The above methodologies have been extensively used over the past few years to assess natural hazards for numerous communities in different parts of Tajikistan, to plan for and implement disaster risk reduction interventions at the local level. This being said, attention paid in those methodologies to risk assessment at the regional level covering entire area of the country's districts, regions and Tajikistan as a whole, has been clearly inadequate. In the meanwhile, it is this kind of data in the form of regional disaster risk assessments that is essential for designing of advanced socio-economic development plans both for individual areas and for the entire country. It is also indispensable in planning of disaster mitigation and response activities. Moreover, public institutions working in the sphere of disaster risk reduction have currently no risk assessment tools and are in an urgent need to get those alongside with the need to strengthen their existing capacity. All of the above predetermined the imperative necessity for development of a disaster risk assessment methodology and tools with due regard for the specified requirements.

To address this far-reaching problem UNDP office in the Republic of Tajikistan (through its Disaster Risk Management Program (UNDP DRMP)) has developed this Disaster Risk Assessment Methodology for the territory of Tajikistan in cooperation with the Information Management and Analytical Center under CoES (IMAC CoES) and with extensive involvement of other partners including government ministries, agencies and organizations with the mandate in assessment of natural hazards as well as REACT partners (Annex 1). The developed methodology is intended to be used in the future as an officially approved tool for disaster risk assessment throughout the country.

1. INTRODUCTION

Disaster Risk Analysis and Assessment (hereinafter "risk assessment") is an integral component of risk management. Risk assessment involves systematic use of all available information to identify natural hazards and assess the risk of possible adverse events. The findings of the risk analysis are used in advanced development planning of territories, planning and implementation of activities aimed at disaster risk reduction.

Risk Assessment Objectives. Disaster risk assessment is an essential component of the National Disaster Risk Management Strategy of the Republic of Tajikistan for 2010-2015 approved by the Resolution of the Government of the Republic of Tajikistan dated 30 March 2010 No.164. Identification of immediate disaster risk assessment objectives is dependent to a considerable extent on the disaster risk management stage wherein the risk analysis is undertaken. Overall we can distinguish three stages of disaster risk management:

- advance assessment and risk reduction;
- risk management during an emergency;
- risk analysis within the framework of disaster response and recovery operations.

At the stage of disaster hazard prevention involving feasibility study for development of territories and advance implementation of risk reduction activities, it is critically important that existing hazards together with the possibility of their actualization (in the form of a natural disaster) are analyzed and potential vulnerability of population and infrastructure facilities to the impact of any given hazards with subsequent development of disaster management activities is assessed. In an emergency and at the time of rescue operations, risk assessment is primarily focused on analysis of development trends of the existing hazard, identification and analysis of the current resilience of facilities and vulnerability of population under the negative impact of natural phenomena including development of recommendations with regard to the priority ranking of emergency activities to reduce immediate risks taking into account available resources. At the stage of disaster response, reconstruction and recovery in disaster affected areas, the goal of risk assessment is to analyze the actual exposure of population and facilities to the negative impact of natural phenomena including assessment of effective damage, analysis of disaster impact on development potential of facilities and territories and identification of newly emerging opportunities and areas of development.

This methodology is focused on addressing risk analysis objectives during the first stage of disaster risk management, i.e. prevention of disaster hazard, feasibility study of sustainable development of territories and implementation of risk reduction activities well in advance.

Objectives of risk assessment activities. Based on the goal at hand, the key objectives of disaster risk assessment are to provide government authorities responsible for decision making with:

- unbiased information on the status of territories and the current levels of existing natural hazards;
- information regarding most hazardous risks and identified "weaknesses" in terms of disaster risk reduction;
- evidence-based recommendations on disaster risk reduction.

The choice of disaster risk assessment methods should take into account analysis goals, type of hazard under analysis and the nature of its occurrence, risk criteria, availability of information and technical resources to carry out the analysis, experience and qualifications of staff tasked with the analysis and some other factors. At the stage of preliminary risk assessment, one can apply qualitative and semi-quantitative risk analysis and assessment methodologies relying on an agreed procedure including utilization of simplified tools (questionnaires, forms, interview schedules, instructions) and practical experience of responsible persons. Quantitative risk analysis and assessment methods are acceptable and admissible for comparison of hazards of different origin within the framework of regional assessment of disaster aftermaths.

It is recommended that the following requirements are observed in selection and application of risk analysis methods:

- the method should be evidence based and suited to the hazards to be analyzed;
- the method should produce results in the form allowing for better understanding of types of hazard manifestation and identification of ways to measure and reduce the risk;
- the method should be replicable and verifiable.

Implementation proper of risk management goals and objectives represents a set of non-structural (political, administrative, legal, institutional and economic) and structural (technical) activities linked with a concrete action program and implemented in a certain order of sequence.

Priorities of disaster risk management and achievement of sustainable development in the Republic of Tajikistan (Component 3) are outlined in the National Disaster Risk Management Strategy of the Republic of Tajikistan for 2009-2015 approved by the resolution of the Government of the Republic of Tajikistan dated 30 March 2010 No.164.

2. GENERAL OVERVIEW; BASICS OF RISK ASSESSMENT WORK

2.1. Risk management. General overview.

Risk management is a systemic application of management policies, procedures and methods to address the tasks of examining the situation, identification, analysis, assessment, processing and monitoring of the risk and exchange of information relevant to risk to ensure reduction of losses and strengthening the trends toward sustainable development. *The risk essentially representing a probabilistic measure of hazard is an inherently concurrent factor of human activities.* Ensuring sustainable development requires organization and implementation of risk management work primarily associated with natural disasters. The goal of risk management is to prevent or minimize human losses and injuries, devastation of infrastructure facilities, damage to property and adverse impact on environment. Risk management requires risk analysis and assessment. Disaster risk analysis enables us to identify existing natural hazards, determine levels of risk associated with the identified undesirable events (in terms of their frequency and consequences) and implement risk reduction measures should the risk exceed an acceptable level.

Risk management comprises four key elements (Fig.1):

(i) Hazard identification and assessment - specification of natural conditions, probability analysis of hazard actualization, specification of the hazard;

(ii) Vulnerability assessment and risk estimation - analysis of potential consequences of risk and vulnerability actualization for given territories and facilities, *inter alia*, on the basis of integral analysis of retrospective data and projected hazard assessment;

(iii) Quantitative risk assessment - analysis of the risk level and degree expressed in a quantitative form allowing to draw conclusions as to acceptability/ inacceptability of the risk;

(iv) Risk control - includes identification of the main actions to reduce or prevent disaster risk including organization and carrying out of risk monitoring.

The developed methodology of regional disaster risk assessment for the territory of Tajikistan encompasses the first three elements of the above risk management procedure: hazard identification and assessment, vulnerability assessment and quantitative risk assessment. The issues of risk control and management, planning, organization and carrying out of activities aimed at disaster risk reduction are beyond the scope of the developed methodology.

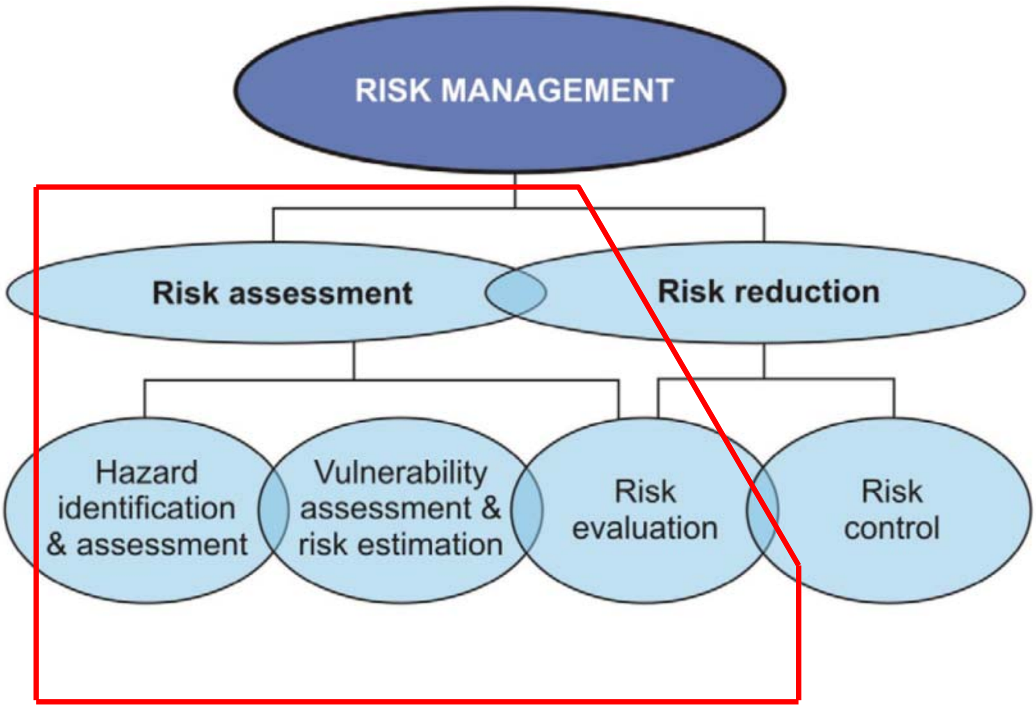

Figure 1: Risk management structure and the place (red box) of disaster risk assessment work within this structure (cited from [Harris&Herbert, 1994] with additions).

This being said, the notion of risk proper is used in development of the disaster risk reduction methodology to measure the hazard and usually refers to an individual (i.e. a single person, and is defined as *individual risk*) or a group of people (defined as *social risk*), assets (physical facilities, property - *physical* or *economic risk*) or environment (*environmental risk*). The notion of risk degree or risk level is used to emphasize that we are referring to a measurable value.

Different variables are used to assess different types of risk:

- *physical risk* is measured in the number of facilities exposed to risk that can potentially sustain damage during a disaster (e.g. number of households, buildings, etc) within a year;

- *full economic risk* is measured in monetary value (e.g. in somonis, US dollars, etc.) of potential damage from a disaster within a year or in percentage of potential damage to the total cost of facilities exposed to risk (in cases when it is impossible to determine the monetary value because there is no data regarding the cost of an individual risk-exposed facility);

- *specific economic risk* - is measured in money terms reduced to an area unit (e.g. in somonis per 1 m^2, per 1 hectare or 1 km^2; in USD per 1 m^2, per 1 hectare or 1 km^2, etc.);

- *individual risk* is determined as a probability of death of one individual from a group of a certain size within one year (e.g. $1*10^{-5}$ pers/pers-year or probability of death of 1 person in every 100,000 population within one year as a result of an emergency);

- *social risk* is measured in the number of persons who can potentially die/ be affected as a result of an emergency within one year (in person-years).

The degree of disaster risk for a certain territory or a certain facility which is usually exposed to multiple hazards is determined based on analysis of aggregate indicators of risks identified during analysis of undesirable events (e.g. occurrence of a landslide or a mudflow, adverse meteorological conditions, etc). In such a case the total degree of disaster risk defined as *integrated risk* is calculated as a sum of separate differentiated risk assessments for a specific hazard.

2.2. Risk analysis and assessment: fundamental notions and definitions

The risk analysis theory is based on a series of scientific concepts. The most fundamental of those is the notion of “risk” proper which is understood as “a probability of adverse consequences or expected losses (loss of human lives, injuries, loss of property, livelihoods, disruption of business activities or harm to environment) as a result of interaction between natural and man-induced hazards, vulnerability and ability to respond to and cope with the consequences” [Living…, 2002]. Another universally accepted and more concise definition of risk is described as “the combination of the probability of an event and its negative consequences” [UNISDR, 2009].

No less important in terms of the risk analysis theory is the definition of “hazard” also interpreted in two ways: [Living…, 2002]:

- likelihood of a threat actualization;

- a potentially dangerous phenomenon, substance, human activity or condition that may cause loss of life or injury, property damage, social and economic disruption, or environmental damage.

UNISDR Terminology on Disaster Risk Reduction uses the second definition of the term “hazard” [UNISDR, 2009].

Experts differentiate several types of hazards:

- natural hazard including geological hazard (with seismic hazard as its subtype), hydrometeorological hazard, medical and biological hazard;

- natural and technological hazard emerging as a result of interaction between natural factors and negative impacts of technogenesis;
- technological hazard including the hazard of technological accidents and disasters.

Another fundamental notion is “vulnerability” which is understood as “a variety of conditions and processes resulting from the interaction of physical, social, economic and environmental factors that increase susceptibility of society to the impact of hazards” [Living…, 2002]. UNISDR Terminology on Disaster Risk Reduction defines the term “vulnerability” as “The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” [UN ISDR, 2009].

The term “risk assessment” proper is defined as “an overall process of risk analysis and evaluation” [GOST 51897-2002]. UNISDR Terminology on Disaster Risk Reduction provides a more detailed definition of “risk assessment” indicating that it is “a methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment” [UNISDR, 2009].

2.3. Classification of risk types

The UNISDR Terminology on Disaster Risk Reduction distingushes the following risk types [UNISDR, 2009]:

- acceptable/ admissible risk;
- disaster risk;
- extensive risk;
- intensive risk;
- residual risk;

As noted above, experts distinguish social, physical, economic and environmental risks depending on the type of facility exposed to risk.

Acceptable/ admissible risk refers to the level of potential losses that a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions. [UN ISDR, 2009]. In engineering terms, acceptable risk is also used to assess and define the structural and non-structural measures that are needed in order to reduce possible harm to people, property, services and systems to a chosen tolerated level, according to codes or “accepted practice” which are based on known probabilities of hazards and other factors.

Disaster risk (in general) is understood as the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period [UN ISDR, 2009]. The definition of disaster risk reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and characteristics of exposed to risk facilities (the patterns of population, specifications of technical facilities and specifics of socio-economic development) disaster risks can be assessed and mapped, at least to the extent which allows taking evidence-based decisions regarding their reduction and/or management.

Extensive risk refers to the widespread risk associated with the exposure of dispersed populations to repeated or persistent hazard conditions of low or moderate intensity, often of a highly localized nature, which can lead to debilitating cumulative disaster impacts [UN ISDR, 2009]. Extensive risk is mainly a characteristic of rural areas and urban margins where communities are exposed to, and vulnerable to, recurring localized floods, and in the context of Tajikistan - to mudflows and landslides.

By contrast to extensive risk *intensive risk* refers to the risk associated with the exposure of large concentrations of people and economic activities to intense hazard events, which can lead to potentially catastrophic disaster impacts involving high mortality and asset loss. [UN ISDR, 2009]. Intensive risk is mainly a characteristic of large cities or densely populated areas, *inter alia*, on the territory of Tajikistan, that are not only exposed to intense hazards such as strong earthquakes, active volcanoes, heavy floods, tsunamis, or major storms but also have high levels of vulnerability to these hazards.

Residual risk refers to the risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. [UN ISDR, 2009]. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery together with socio-economic policies such as safety nets and risk transfer mechanisms.

2.4. Key approaches and methodologies of risk analysis

To date, a great variety of methods for and approaches to risk assessment have been developed. When selecting a risk analysis method one should consider whether the study is to be performed in a staged manner, what goals and objectives it is supposed to achieve, understand the type and nature of hazards, know resources available for the analysis, experience and qualifications of the responsible persons, availability of required information and a number of other factors. The chosen risk analysis method should comply with the following requirements:

- the method should be evidence-based and match the relevant organizational level;
- the method should yield results in the form making it possible to better understand the risk nature and develop risk reduction plans;
- the method must be reproducible and verifiable.

Listed below are the main methods recommended for risk analysis.

The “check-list” and “what-if” methods or combination thereof are referred to the qualitative group of hazard assessment tools. They are based on review of whether the natural conditions on the territory, community or facility in question comply with the existing safety requirements. The outcome of the “check-list” method is a list of questions and answers (filled out questionnaires) regarding compliance of natural conditions on the territory, community or facility in question with safety requirements that provide data needed to develop and implement the basic disaster risk reduction activities and improve safety. The “check-list” method differs from the “what-if” approach since it allows for collection of more comprehensive base-line information and presentation of more detailed results. The “check-list” and “what-if” methods are the easiest (particularly if they are conducted using questionnaires and standardized forms facilitating the practical analysis and presentation of the findings), the cheapest (findings can be obtained by a small group of people within several days) and the most effective tool to study facilities characterized by an insignificant disaster risk level. The above methodological approaches were standardized in the form of risk assessment guidelines (MECO methodology) developed by a group of international organizations active in the field of disaster risk reduction in Tajikistan.

Failure Mode and Effects Analysis (FMEA) is used for qualitative assessment of technological risks. An essential feature of this method is that it reviews every element of a technical system or a part thereof to identify possible future failures (type and cause of failure) and the effects of the failure on the technical system.

The failure mode and effects analysis may be further expanded to **Failure Mode, Effects and Critical Analysis** - (**FMECA**). In the latter case every type of failure is ranked with due regard for two risk components - probability (or frequency) and severity of effects of the failure hazard. In qualitative risk analysis outcomes are presented in the form of matrices listing risk receptors (territories, communities and individual facilities) and hazards together with their frequency, effects, severity and recommendations on hazard reduction. Table 1 shows the recommended values (indices) of risk level and criteria sorted by the probability of hazard actualization (hazardous event) and severity of its effects. The analysis must distinguish three groups of risk receptors that can sustain losses: *population, physical facilities and environment.* As a rule, severity of effects is categorized based on the following criteria:

Catastrophic effects resulting in loss of life, significant physical and economic damage, and irreparable harm to environment;

Critical effects result in a threat to human lives as well as physical and economic damage suffered by population, facilities and environment;

Non-critical effects pose no threat to human lives but may result in some physical and economic damage to population, facilities and environment;

Negligibly slight effects refer to a hazard the effects whereof cannot be classified under any of the previous categories.

Criteria in Table 1 can be applied to hazard ranking and establishment of risk level. In this case the ranking of A corresponds to the highest (unacceptable) risk level for a facility which requires urgent risk reduction measures. Respectively, the letters B and C correspond to the intermediate risk level and the rating of D is an indicator of the most hazard-free conditions. The problem of the method in question lies in the complexity of integrating individual hazard contributions in the overall risk level.

The FMEA and FMECA methods are applied to analyze facilities and territories characterized by complex natural conditions. These methods can be implemented by a group of 3-7 experts within several days/ weeks.

The methodological approach based on the FMECA method was adopted in the Risk Assessment Guidelines (FOCUS methodology) developed by Focus Humanitarian Assistance, an NGO currently working in the sphere of disaster risk reduction in Tajikistan.

Table 1.

Sample matrix of "hazard actualization probability versus severity of effects"

Expected frequency		Severity of actualization of hazard effects (1/year): Catastrophic	Critical	Non-critical	With negligibly slight consequences
Frequent event	>1	A	A	A	C
High likelihood	1 - 10^{-2}	A	A	B	C
Possible event	10^{-2} - 10^{-4}	A	B	B	C
Rare event	10^{-4} - 10^{-6}	A	B	C	D
Virtually improbable event	<10^{-6}	B	C	C	D

Risk level:

A - high level; a detailed risk analysis must be done and urgent risk reduction measures need to be taken;
B - medium level; a detailed risk analysis is advisable with subsequent implementation of risk reduction measures;
C - low level; risk analysis and disaster risk reduction measures are recommended;
D - negligible level; no analysis and risk reduction measures are required.

The method of **Hazard and Operability Study (HAZOP)** studies deviations characterizing the assessed facility from intended parameters and the possible effects that may result in a hazard. According to its complexity and quality of results HAZOP corresponds to the level of FMEA and FMECA. Application of the HAZOP method is justified in disaster risk assessment of territories and facilities equipped with a comprehensive natural hazards monitoring system when the threshold indicators - actualization harbingers of natural hazards have been identified. To characterize indicators describing development of natural hazards the following guide words are used: "NO OR NOT", "MORE", "LESS", "AS WELL AS", "PART OF", "OTHER THAN", "REVERSE", etc. Application of the guide words helps the assessment team to evaluate the situation. The extent of hazard can be quantified through assessment of the likelihood and severity of consequences of a given situation based on analysis of critical criteria similar to the analysis under FMECA (Table 1). HAZOP similarly to FMECA is based on identification of hazards and their ranking. Disadvantages of those methods lie in the fact that they are hard to apply to a combination of events resulting in losses.

The group of **logical-diagrammatic methods** comprises "**failure tree analysis**" and "**event tree analysis**". The logical-diagrammatic methods are mostly used in assessment of technological risks. Past experience shows that emergence and development of major technological accidents is usually characterized by a combination of precarious local events arising with different frequency at different stages of an accident (failure of equipment, human errors, external impact, destruction, emissions, spills, dispersion of agents, inflamation, explosion, intoxication, etc). To determine cause-effect relationship between those events experts use the logical-diagrammatic method of "failure tree analysis" focusing on review of the possible causes that triggered the emergency condition and trying to establish its frequency. The "event tree analysis" is applied to estimate how the emergency condition will be developing. The methods of "event tree" and "failure tree" analysis are labor intensive and are usually applied in project analysis and upgrading of complex engineering systems and production operations.

The method of **quantitative risk analysis** is based on calculation of risk indicators. It can comprise one or more of the above methods (or use their results).

Quantitative risk assessment based on loss and damage analysis is primarily focused on deriving an economic assessment of damage from possible development of contemporary adverse natural processes and risk of possible social losses. This approach is of a more systematic nature and includes, on the one hand, an analysis of potential development of dangerous natural processes in combination with a probabilistic assessment of their individual manifestations (landslides, mudflow processes, earthquakes) and, on the other hand, a vulnerability analysis of technological facilities with subsequent assessment of economic damage and the level of possible social losses in case of natural disasters.

Quantitative analysis requires a rather high proficiency of the survey team, a large body of information on frequency of dangerous phenomena recurrence with due regard for specific natural conditions of the area, duration of stay on the territory or close to the facility, population density and other factors. Quantitative risk analysis is most effective:

- in design of advance development programs;
- in risk assessment for homotypic facilities, e.g. typical apartment buildings;
- whenever there is a need to obtain an integrated assessment of disaster impact on population, physical facilities and natural environment;
- in development of priority measures to ensure emergency preparedness in an area highly prone to natural hazards.

A certain disadvantage of quantitative risk analysis is its high labor intensity which is well justified since the method makes it possible to carry out comparative analysis of risk level based on quantitative assessment criteria for extensive territories. In the future, the methodology of regional disaster risk assessment for the territory of Tajikistan will use the **quantitative risk assessment method based on damage and loss analysis.**

2.5 Organizational levels of risk assessment

Goals and objectives of risk assessment are heavily contingent on the organizational level of assessment work. We distinguish the following risk assessment levels:

Local level refers to risk assessment at the level of individual communities or small, mostly rural, populated areas.

Sectoral level refers to risk assessment either at the level of individual economic sectors, e.g. assessment of water-logging risks related to melioration activities, or with regard to larger individual territories which are geographically isolated , e.g. mountain valleys or territories characterized by similar natural conditions.

Subregional level refers to risk assessments for individual administrative territories such as provinces (oblasts), groups of districts and individual districts featuring a combination of different natural conditions.

National level refers to assessments of the entire territory of the Republic of Tajikistan using a uniform methodological basis.

The interplay of risk assessment objectives addressed at different organizational levels is shown in Figure 2.

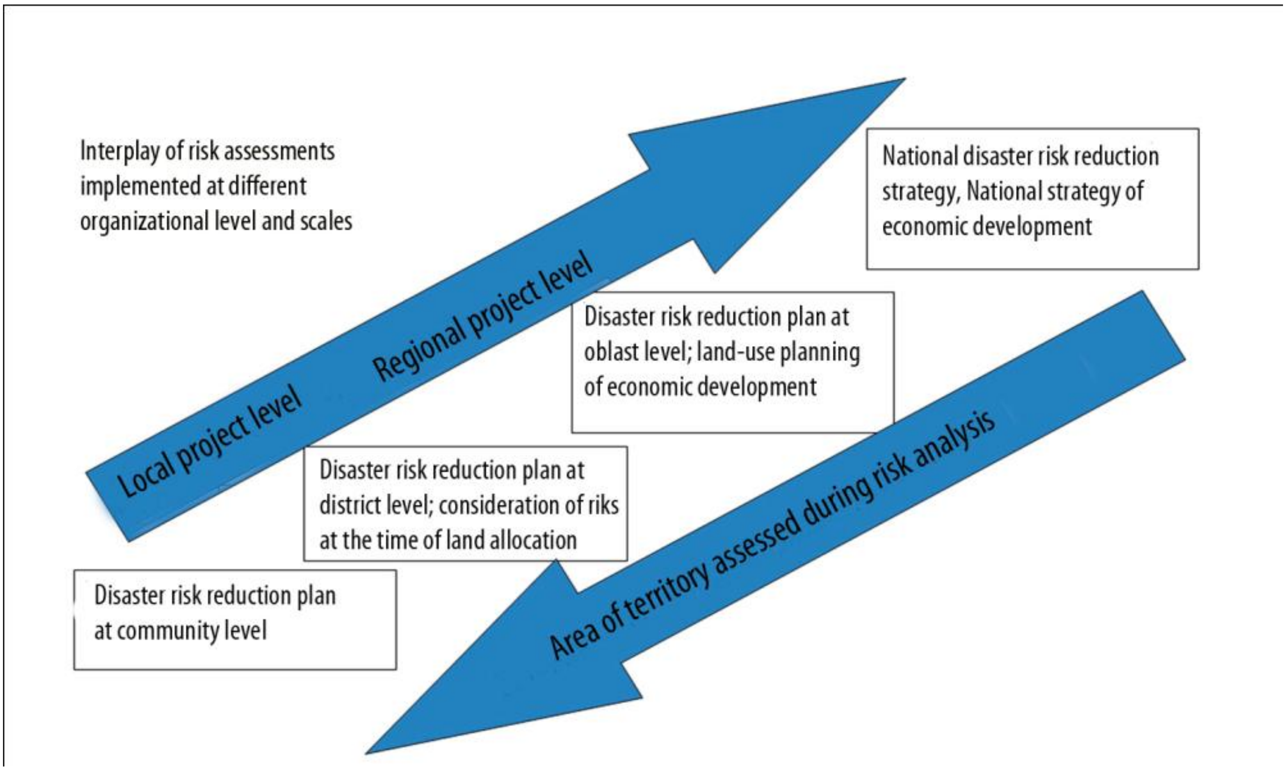

Fig.2. Interplay of risk assessment objectives addressed at different organizational levels.

3. RISK ASSESSMENT METHODOLOGY FOR NATURAL HAZARDS ON THE TERRITORY OF TAJIKISTAN

3.1. Main stages and sequence of analysis

Assessment of risks from natural hazards is a step-by-step procedure which is implemented in a staged manner. This being said, analysis of natural hazards and subsequent risk assessment focus on:

- identification, review and presentation of objective natural risk constituents unaffected by human perceptions in a qualitative and, more importantly, quantitative form;

- ensuring compliance of the planned activities with safety and durability requirements, least-cost operation and achievement of the set objectives within a given timeframe.

The main sub processes envisaged within the risk assessment process are as follows:

- overview of natural conditions;
- identification of hazards
- evaluation of hazard level;
- identification of risk receptors;
- vulnerability assessment of risk receptors;
- risk assessment including analysis and quantitative assessment of risk;
- risk processing.

It is also essential to plan for such subprocesses as risk monitoring, information sharing on risk related issues (including consultations with stakeholders) and training. At the same time, the natural conditions of Tajikistan necessitate more detailed requirements as to the quantitative risk assessment including differentiated and integrated risk assessments as well as precise compliance with risk processing procedures, including vulnerability assessment of facilities through assessment of possible effects of hazard actualization. Another important stage of risk assessment is preparation and presentation of risk analysis results to stakeholders for future use.

The methodological approach to assessment of natural risks recommended in these guidelines is shown in a diagrammatic form in Figure 3.

The general sequence chart for analysis of natural hazards and risks for land use planning, construction and operation of facilities on the territory of Tajikistan is shown in Figure 4.

In many cases it proves extremely difficult, unfeasible or economically impractical to carry out an exhaustive risk assessment for all possible natural hazards and all possibles ways the hazards may affect risk receptors (population, territories, individual facilities) in the area under survey. In such a situation reduction in the number of considered risk factors would be well warranted. The analysis comprises six stages:

1. Selection of the most catastrophic and/or adverse risk factors which are considered top-priority for the assessed territory;

2. Identification of typical and the most likely scenarios of actualization of natural hazards with respect to the selected risk factors;

3. Carrying out risk analysis for reasonably selected scenarios using standard methods for observation of natural conditions, recurrence data for hazardous natural phenomena and their destructive potential;

4. Extrapolation of results obtained for the selected factors and scenarios to other problems present in the region;

5. Comparison of information on different risk types (physical, economic, social) for different areas to rank the factors affecting the risk level.

6. Combined review of quantitative assessments for different types of risk.

3.2. Planning and organization of work

Addressing organizational issues. Listed below are objectives related to planning and management of risk assessment activities:

- review the existing situation to enable the process of natural hazard assessment;
- manage activities aimed at identification of natural hazards;

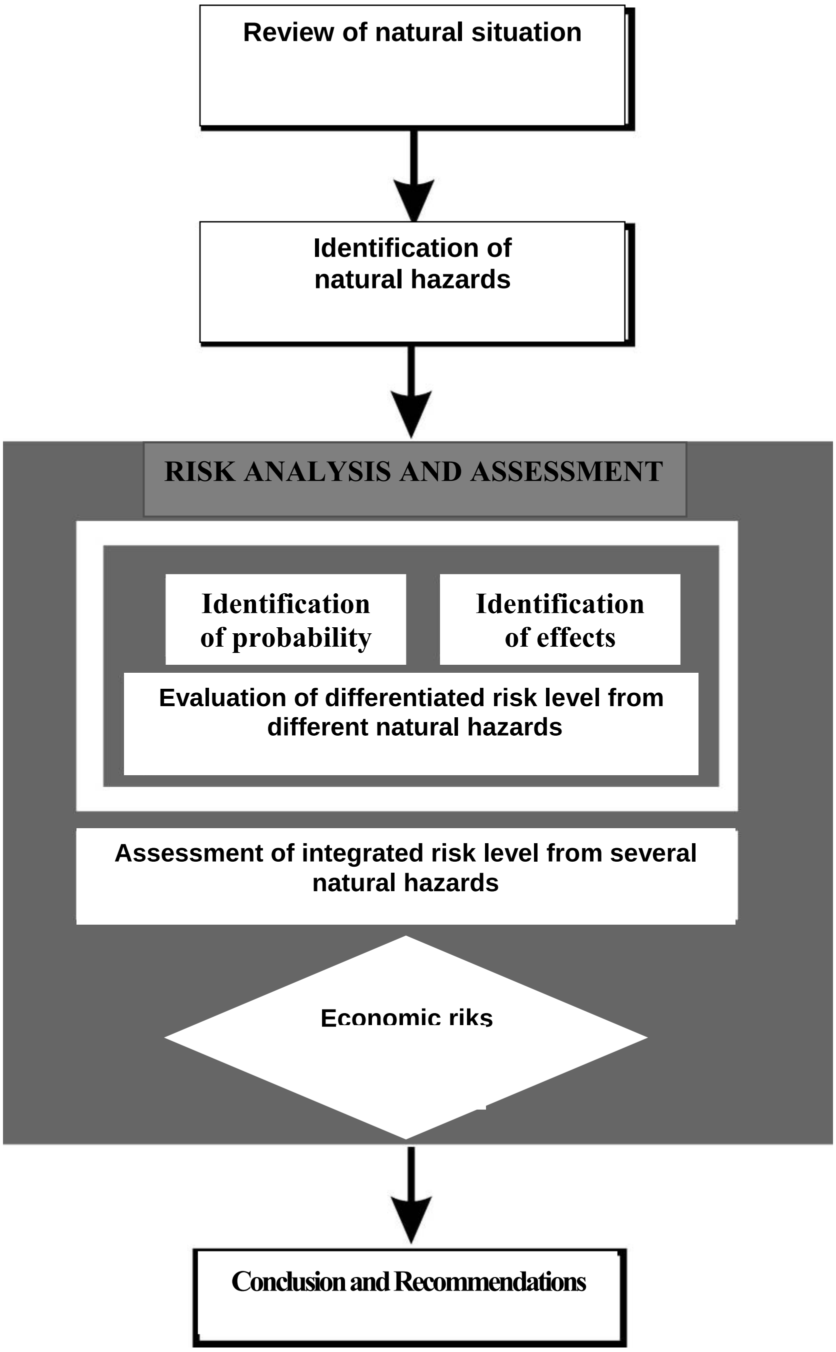

Fig. 3. Consolidated methodology for implementation of natural risk assessments

GENERAL SEQUENCE CHART

for analysis of natural hazards and risks for the purpose of land use planning, construction and operation of facilities on the territory of the Republic of Tajikistan

Identification and prediction of natural hazards:

1. Please indicate the genesis of primary and secondary natural hazards that have affected or may affect the territory and facilities under assessment. Also indicate the place, time and conditions of actualization of any such hazards.
2. What was the stability, intensity, recurrence (frequency), on-set speed and duration of impact produced by those hazards without any preventive measures in the past and what are the projected values for the above indicators?
3. What will be the intensity, recurrence, on-set speed and duration of impact from the natural hazards with different options for their prevention?

→

Vulnerability assessment of territories, construction sites and population with regard to natural hazards:

1. How is the territory under assessment used and/or what are the plans for its future use?
2. What kind of facilities (according to their designation and key characteristics) are located or envisaged to be constructed on the territory in question?
3. What is the number, composition, distribution and mobility of population within the territory or facilities under assessment?
4. Identify vulnerability of individual parts of the territory, facilities, their systems and population to the predicted natural hazards of a certain type and intensity.
5. Determine vulnerability of facilities, engineering protection structures and protected territories, construction sites and population to the natural hazards.

↓

Assessment of risks posed by natural disasters:

1. What development scenarios and adverse primary and secondary effects of natural hazards are possible?
2. What is the probability that these scenarios will actualize?
3. What will be the losses from individual manifestations and from all hazards?
4. What will be differentiated and integrated risk of losses from individual manifestations and from all hazards?
5. How will the development scenarios, probability and extent of losses, differentiated and integrated risks change after prevention measures are applied?

←

Disaster Risk Management:

1. What measures are envisaged to reduce and prevent the risk?
2. Which risk levels should be considered acceptable (admissible)?
3. What are the current or planned arrangements for monitoring of natural hazards, status of facilities, losses and risks?
4. What is the perception of population and authorities with regard to the identified hazards, risks, prevention and monitoring measures?
5. What additional measures are needed to reduce and monitor the remaining risks?

↑ (to Identification and prediction of natural hazards)

Fig.4

- management of activities aimed at analysis and assessment of risk elements (vulnerability of population, territories and facilities);

- initiation and implementation of activities aimed at collection and processing of source information until the level and reliability of the source data is sufficient for quantitative risk assessment;

- identification and registration of any problems related to the risk assessment work and taking corrective measures, as appropriate;

- resolving contradictions arising during risk assessment work;

- continuous and timely information sharing on risk related issues in the course of risk assessment work with all stakeholders involved in the assessment process;

- management of activities aimed at quantitative assessment of natural risks;

- verification of assessment findings and their analysis for reliability;

- establishment of a documentation system ensuring traceability of the implemented procedures and presentation of the risk assessment findings.

Discussions in the course of risk analysis and presentation of risk assessment findings. The resulting risk assessment materials are used as the source data in management decision making regarding land-use planning and sustainable development of territories, and in design and implementation of activities aimed at disaster risk reduction. Any moot points arising in the course of risk assessment work must be addressed through participatory consultations ensuring resolution of issues related to hazard and vulnerability assessment. The consultations may be either formal or informal but all discussions and decisions related to risk issues must be properly recorded and documented.

Discussions of risk related issues may include:

- identification and assessment of natural hazards;

- analysis of the established list of all risk receptors (population, industrial and agricultural facilities, etc.);

- analysis of the level of all risk types and activities associated with their processing during assessment;

- identification and adoption of any changes in risk data and repeated analysis of the changes;

- assessment of efficiency of the risk analysis process;

- discussion of partner coordination issues in the context of the risk assessment work.

Requirements as to the deliverables must be established at the stage of planning of the risk assessment work.

Planning of work on disaster risk assessment. Planning of work on disaster risk assessment describes a structured risk-analysis process which should be applied in implementation of the risk assessment methodology. The work plan may include the following sections (or references to respective documents):

- scope of work and working arrangements, including goals and objectives of the risk assessment;
- proposed methodology of risk assessment, its processes and subprocesses;
- a list of all types of potential natural hazards to be reviewed during the risk assessment;
- a list of all types of potential risk receptors to be considered during the risk assessment;
- responsibilities and authority of all parties involved in the assessment;
- arrangements for internal and external information sharing;
- a program of discussions and consultations to be held during the assessment work;
- document forms for all stages of work;
- analysis of risk assessment processes and procedures;
- procedures to ensure linkages with other similar projects and works;
- a program for implementation of necessary organizational procedures.

The risk assessment work-plan should be reviewed and adjusted on a regular basis in line with the work progress.

3.3. Distribution of functions of public authorities in Tajikistan with regard to risk analysis and assessment.

Executive authorities under the Government of the Republic of Tajikistan (ministries, state committees and agencies, their regional subdivisions, subordinate organizations and public institutions) involved as partners in risk assessment activities may be categorized into several groups:

1. Executive authorities, public organizations and institutions tasked with research and analysis of natural conditions on the territory of Tajikistan, including those responsible for prediction of natural hazards and assessment of effects of natural disasters;
2. Executive authorities with the main responsibility to exercise government regulation

of the socio-economic development, industrial and agricultural production, ensuring uniformity of technical specifications and regulations and their enforcement on the territory of Tajikistan;

3. Executive authorities responsible for development and enforcement of the government policy and regulations regarding formulation of short-term, mid-term and long-term strategies, programs and forecasts of socio-economic development of the country and its individual regions, including disaster risk reduction programs.

Executive authorities under the Government of the Republic of Tajikistan (ministries, state committees and agencies, their regional subdivisions, subordinate organizations and public institutions) forming the first group are involved in risk assessment activities as partners facilitating identification and analysis of natural hazards (in accordance with their respective areas of competence). This group includes:

- The Ministry of Land Reclamation and Water Resources and its subordinate organizations responsible for analysis of hydrometeorological hazards (water-logging, etc);

- Main Directorate of Geology under the Government of the Republic of Tajikistan and its subordinate organizations, responsible for analysis and study of geological hazards (specifically, dangerous exogenic geological processes);

- State Hydrometeorological Agency responsible for analysis of hydrometeorological hazards (dangerous meteorological phenomena and natural hazards caused by them, including avalanches, etc);

- Institute of earthquake engineering and seismology under the Academy of Sciences of Tajikistan responsible for analysis and studies of geological hazards (specifically, seismic hazard).

Executive authorities under the Government of the Republic of Tajikistan (ministries, state committees and agencies, their regional subdivisions, subordinate organizations and public institutions) forming the second group are involved in risk assessment activities as partners - on the one hand, providing data on social, industrial and agricultural facilities, populated areas, territories that can potentially become risk receptors, and on the other hand, are the end-users of risk assessment data with reference to their core functions, e.g. approval of licenses for certain types of economic activities (within the scope of their competence). This group includes:

- Ministry of Health;

- Ministry of Agriculture and Nature Protection;

- Ministry of Transport and Communications;
- Ministry of Energy and Industry;
- State Committee for Land Management, Geodesy and Cartography under the Government of the Republic of Tajikistan;
- Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan;
- Agency for Construction and Architecture under the Government of the Republic of Tajikistan;
- Statistical Agency under the President of the Republic of Tajikistan.

Executive authorities under the Government of the Republic of Tajikistan forming the third group are involved in risk assessment work primarily as users of the risk assessment data in discharge of their functions. This group includes:

- Ministry of Finance;
- Ministry of Economic Development and Trade.

The work to assess the risk of natural hazards, review the risk-analysis findings and use the obtained data should be organized with involvement of all concerned executive authorities under the Government of the Republic of Tajikistan.

3.4. Requirements for presentation of source information.

Tabular information for risk assessment of natural hazards should mostly be provided in an electronic format as Excel spreadsheets (*.xls) or Access database files (*.mbd). The presented tabular data describing development of dangerous natural processes and location of risk receptors must contain spacial (coordinate) data with the level of accuracy sufficient to tie the data to a topographic base at the scale of 1:200,000 – 1:100,000. As an exception during the initial stages of work, tabular and narrative information can be presented in paper form.

In case the source cartographic information is presented in hard copy it is necessary to have it scanned with the resolution of not less than 300 dpi in *.tif format for the purpose of subsequent georeferencing.

Cartographic information for the purpose of risk assessment of natural hazards is generally provided in the electronic format adopted in ArcGIS geodatabase or as shape-files with a mandatory description of the projection (for shape-files in *.prj format) used to represent the prepared information. In some cases, cartographic information can be presented in the form of georeferenced raster images with a mandatory description of the projection used for georeferencing. As an exception during the initial stages of work, cartographic information can be presented in paper form.

4. IDENTIFICATION OF NATURAL HAZARDS

4.1. General classification of natural hazards observed on the territory of Tajikistan

Listed below are the types of natural hazards observed on the territory of Tajikistan which should be analyzed in the process of disaster risk assessment:

- seismic hazard;
- hazards associated with processes affecting slopes (landslides, landfalls, rockslides, etc.);
- mudflow hazard;
- avalanche hazard;
- flood hazard (as a result of snow melting, heavy precipitation, lake outbreaks);
- hazard associated with water-logging;
- hazard associated with erosion processes.

4.2. Assessment of hazardous natural processes prevalent on the territory of Tajikistan

Over 90% of Tajikistan's territory of 143.1 thousand km^2 is covered by mountain systems. Due to its geographical features Tajikistan is believed to be one of the countries with the highest exposure to natural disasters. The above characteristics of the country's geographical situation predetermine a vast prevalence of such natural hazards as earthquakes, landslides, mudflows, avalanches, droughts, etc. According to IMAC CoES, over 2,330 emergencies of natural origin occurred in the country during the period from 1996 to 2010. Therefore, the average number of natural disasters occurring in Tajikistan annually is more than 150. They result in significant losses (particularly in vulnerable households) and slow down the rate of economic development in the country. Over the period from 1997 to 2009, more than 930 people lost their lives as a result of natural disasters in Tajikistan whereas the total economic damage just for the period from 2000 to 2007 constituted over USD 280 mil. [National Strategy, 2010].

Listed in Table 2 below are some of the most active and dangerous geological processes registered on the territory of Tajikistan based on IMAC CoES data (over the observation period from 1969 to 2004):

- landslide processes - 835 affected areas, of which more than 28% should be referred to the category of extremely dangerous and catastrophic;

- mudflow processes - over 700 affected areas, of which more than 21% should be referred to the category of extremely dangerous and catastrophic;

- processes of ravine (over 400 affected areas) and river (lateral) (over 100 affected areas) erosion;

- avalanche formation processes;

- rockfalls, formation of rocklides and screes;

- karst and suffosion processes.

Climatic conditions of Tajikistan play a large part in development of natural disasters in the country. Almost all hazards existing in Tajikistan are associated with climate or weather conditions. Heavy rains cause mudflows, floods, and often enough become the main factor in triggering of landslides. The provided analysis of emergencies of natural origin (by triggering natural processes) recorded in IMAC CoES database over the period from 1996 to 2010 shows that meteorological and climatic phenomena (windstorms, cold snaps, heavy precipitation, including thick squall, and droughts) have served as an immediate cause of about 40% of recorded natural disasters. At the same time, it should be noted that with regard to emergencies caused by mudflow processes (about 20% of recorded disasters), freshets and floods (over 13% of recorded disasters) their direct linkage with heavy precipitation was established in less than 30% of all instances, whereas in other cases these linkages can only be established through additional studies. Thus, the above facts corroborate the conclusion that meteorological and climatic factors have a major part (cumulatively up to 73% of all emergencies) in triggering of natural disasters in the context of Tajikistan.

Another significant type of emergencies of natural origin in Tajikistan are disasters caused by geological factors such as earthquakes (about 9% of recorded disaster events), landslides (over 9% of recorded disaster events) and others (rockfalls, rockslides, soil subsidence, etc).

Table 2.

Hazardous natural processes registered on the territory of Tajikistan
(during the period from 1969 to 2004)

Process type	Number of sites affected by the processes				
	Total	including			
		extremely dangerous and catastrophic	dangerous	potentially dangerous	presumably potentially dangerous
Landslide processes	835	240	292	244	59
Mudflow processes	701	152	223	281	45
Ravine erosion	409	104	142	132	31
Avalanches and rockfalls	66	14	13	31	8
River (lateral) erosion	103	15	36	46	6
Karst and suffosion processes	73	30	30	10	3

Cited from (Shomahmadov, 2010)

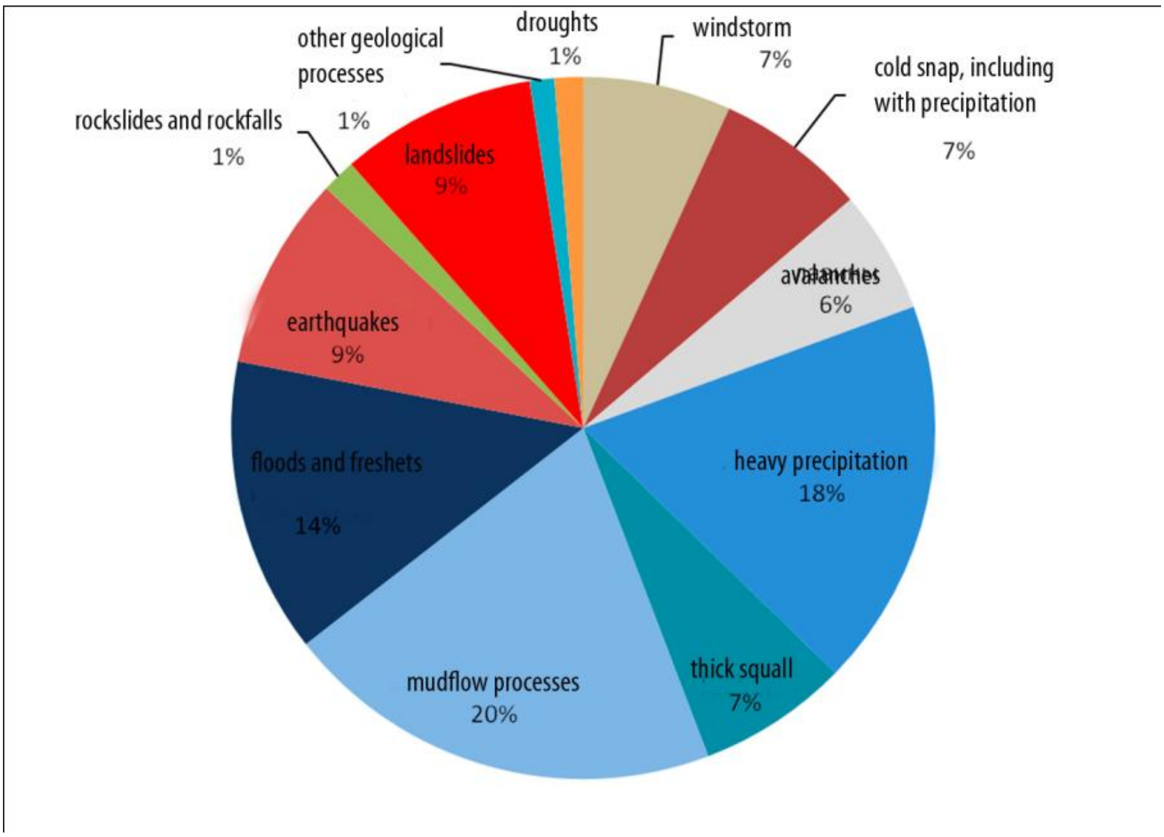

Fig.4. Distribution of emergencies of natural origin over the period from 1996 to 2010

by type of natural processes (compiled by O.V.Zerkal based on IMAC CoES data).

At the same time, it should be noted that despite their significantly lesser share in triggering of emergencies, geological processes are overall more dangerous and catastrophic. For example, according to the Institute of Earthquake Engineering and Seismology more than 40 thousand people perished in Tajikistan over the last 100 years as a result of earthquakes (about 15 thou. persons in Karatag earthquake of 1907; several hundreds of persons - in Sarez earthquake of 1911, about 30 thou. persons - in Khait earthquake of 1949, several dozens of people - in Kairakkum earthquake of 1985, and about 300 people - in Hissar earthquake of 1989).

This being said, the highest catastrophic effects (in terms of human casualties) during the period from 1996 to 2010 were actually caused by emergencies associated with mudflows (over 51%) and snow avalanches (over 29%) (Fig. 5).

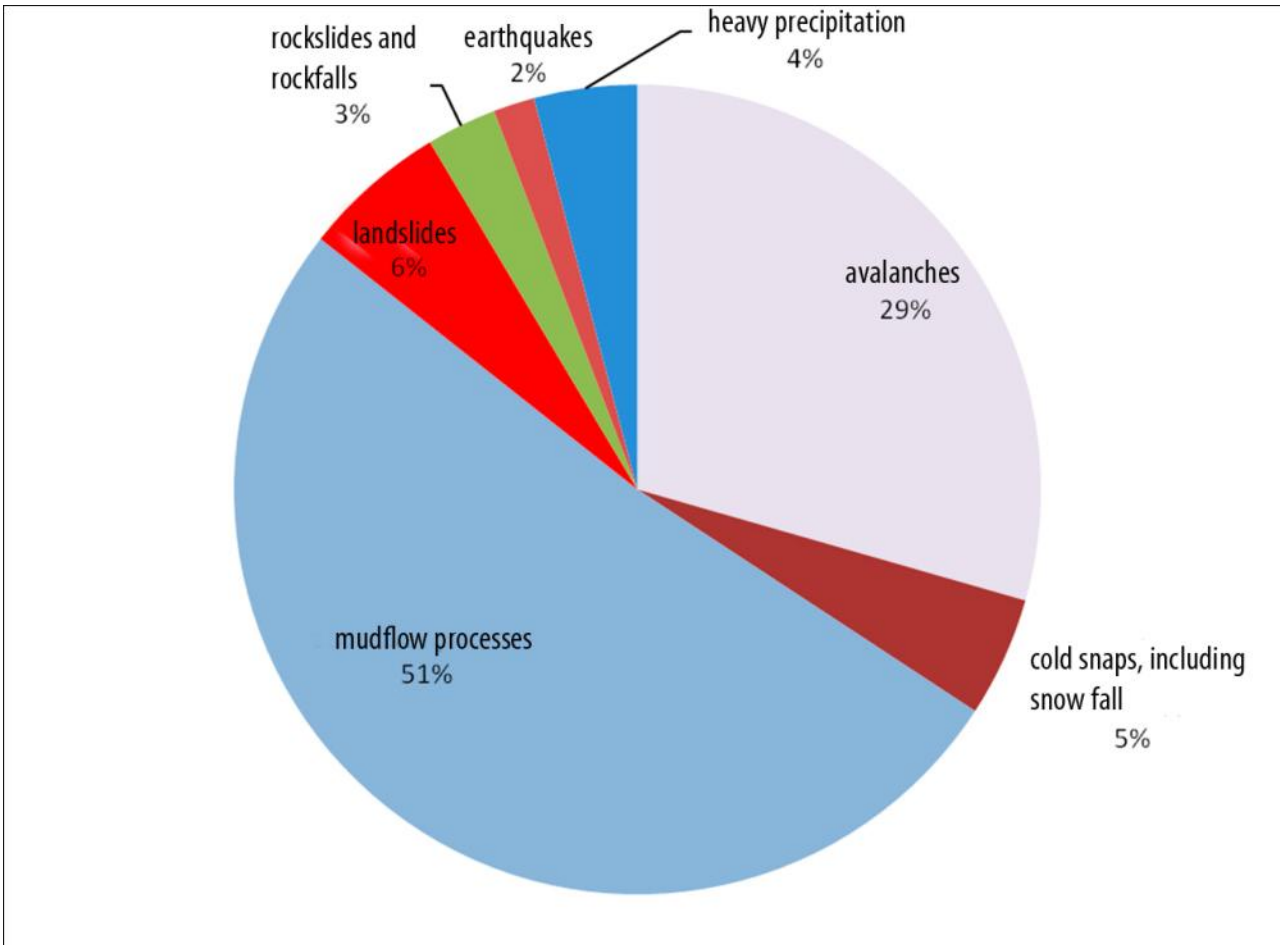

Fig.5. Distribution of emergencies of natural origin which resulted in loss of life over the period from 1996 to 2010 by type of natural processes (compiled by O.V.Zerkal based on IMAC CoES data).

4.3. Exposure analysis of the territory of Tajikistan to different hazard types

A cartographic description of exposure of the country's territory to different types of natural hazards (based on IMAC CoES data) is provided in Figures 6-10. The available data shows that the territory of Tajikistan can be divided into three categories of areas based on the level of seismic hazard (Fig. 6). Areas falling under the first category may be affected by earthquakes with the magnitude of 7.3-8.0. Earthquakes with the magnitude of 6.5-7.2 are possible in areas referred to the second category. And lastly, areas of the third category may be affected by earthquakes with the magnitude of 5.6-6.4.

Figure 7 shows spacial distribution of areas affected by dangerous exogenic geological processes (landslides, rockslides, erosion and karst) on the territory of Tajikistan. Figure 8 provides a cartographic description of exposure to mudflow processes. Avalanche hazard for the territory of Tajikistan is described in Figure 9 and development of erosion processes is shown in Figure 10.

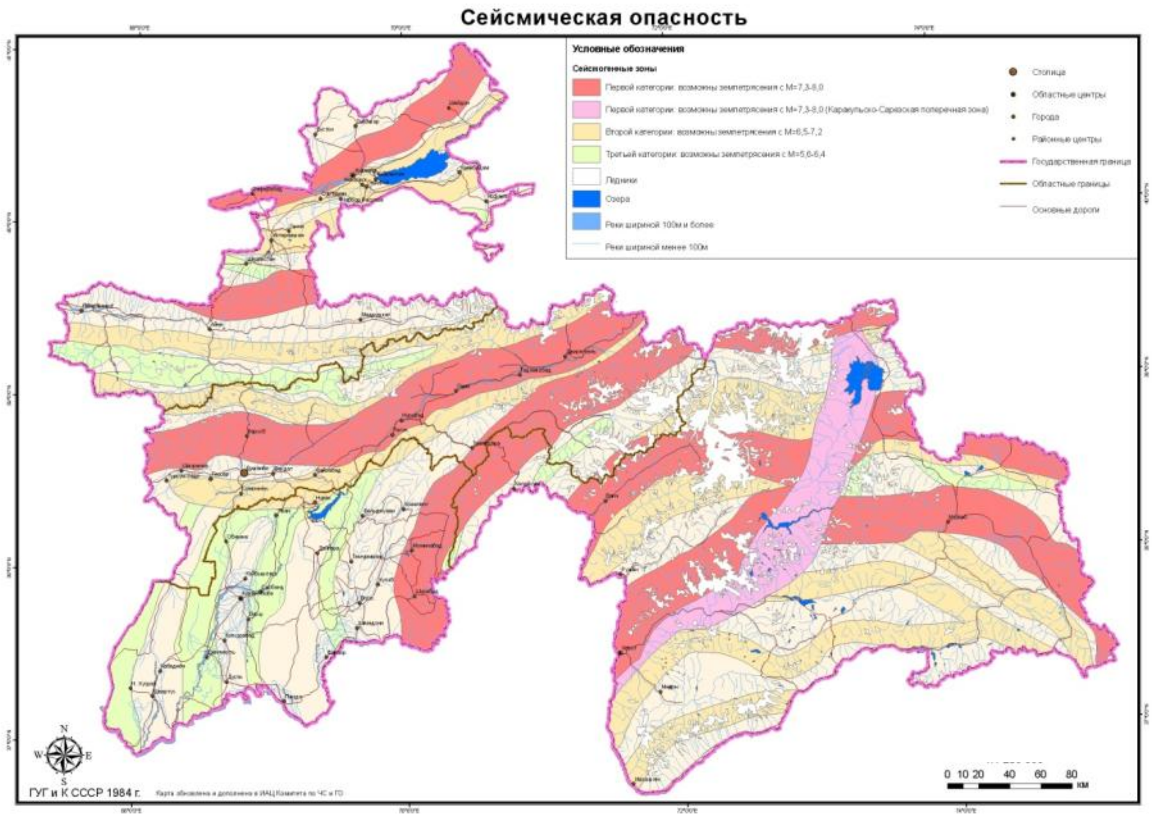

Fig.6. Seismic hazard map of Tajikistan

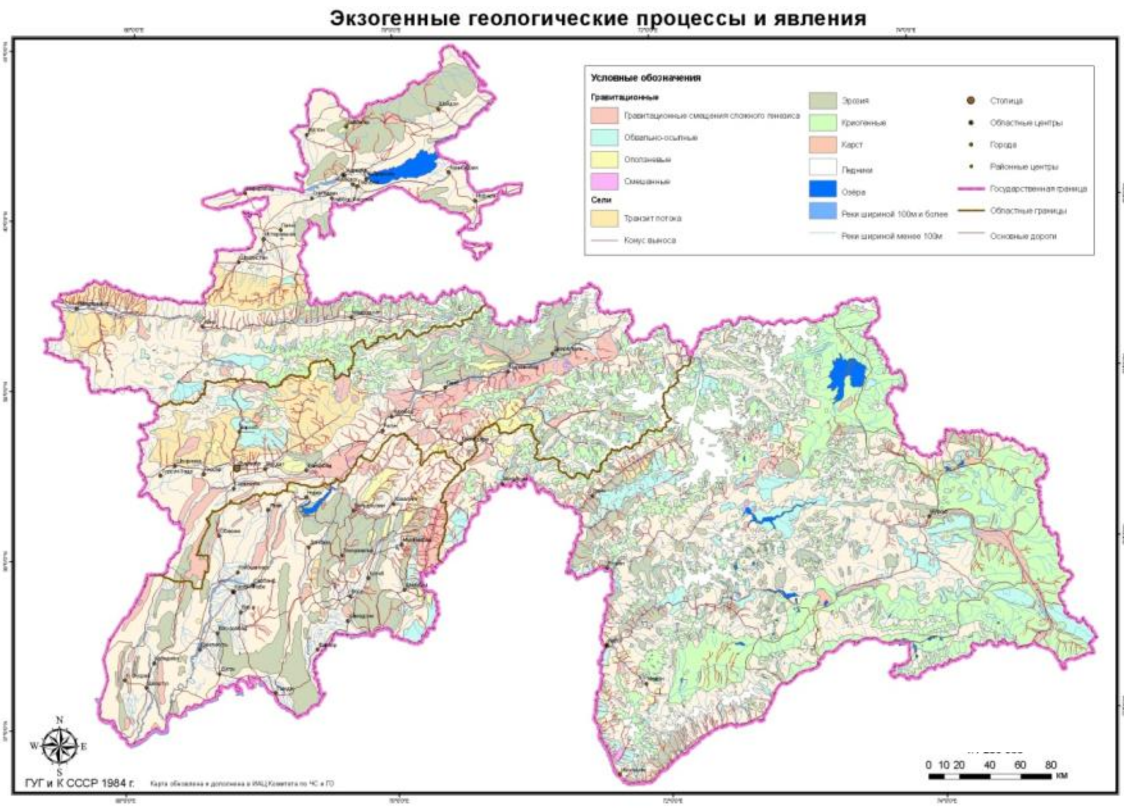

Fig.7. Map showing dangerous exogenic geological processes (landslides, rockslides, erosion and karst) on the territory of Tajikistan.

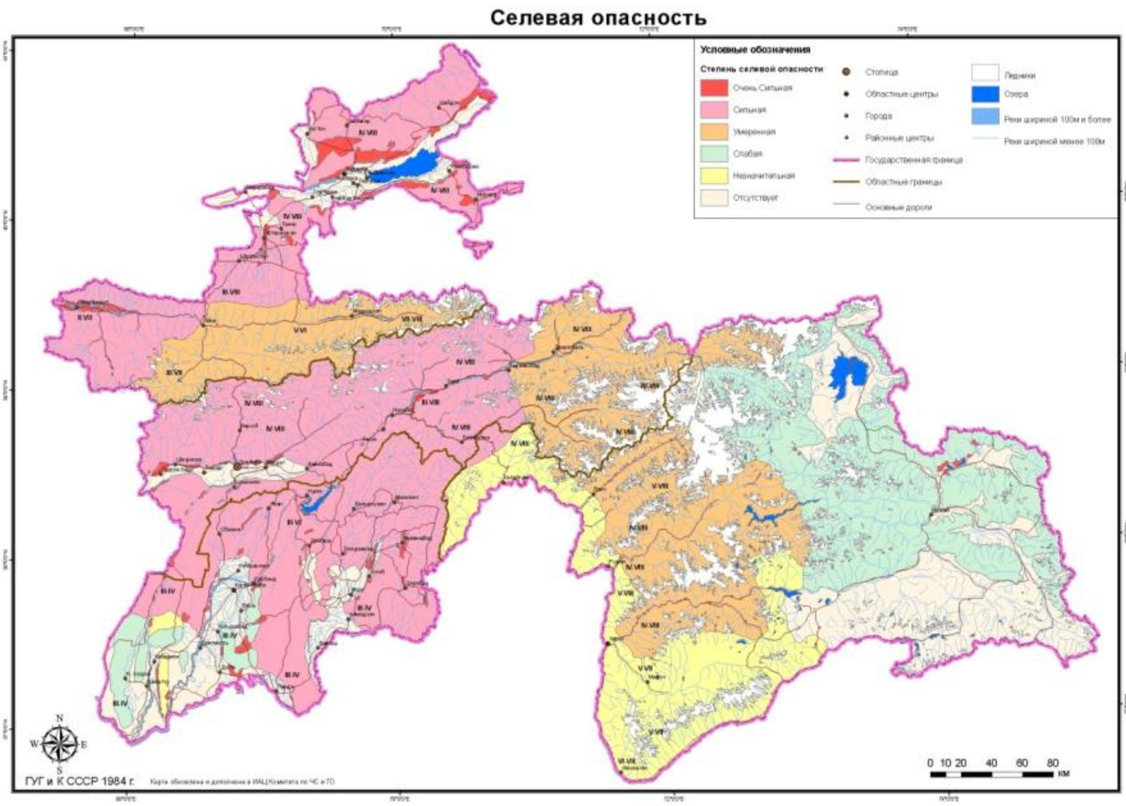

Fig. 8. Areas on the territory of Tajikistan affected by mudflows.

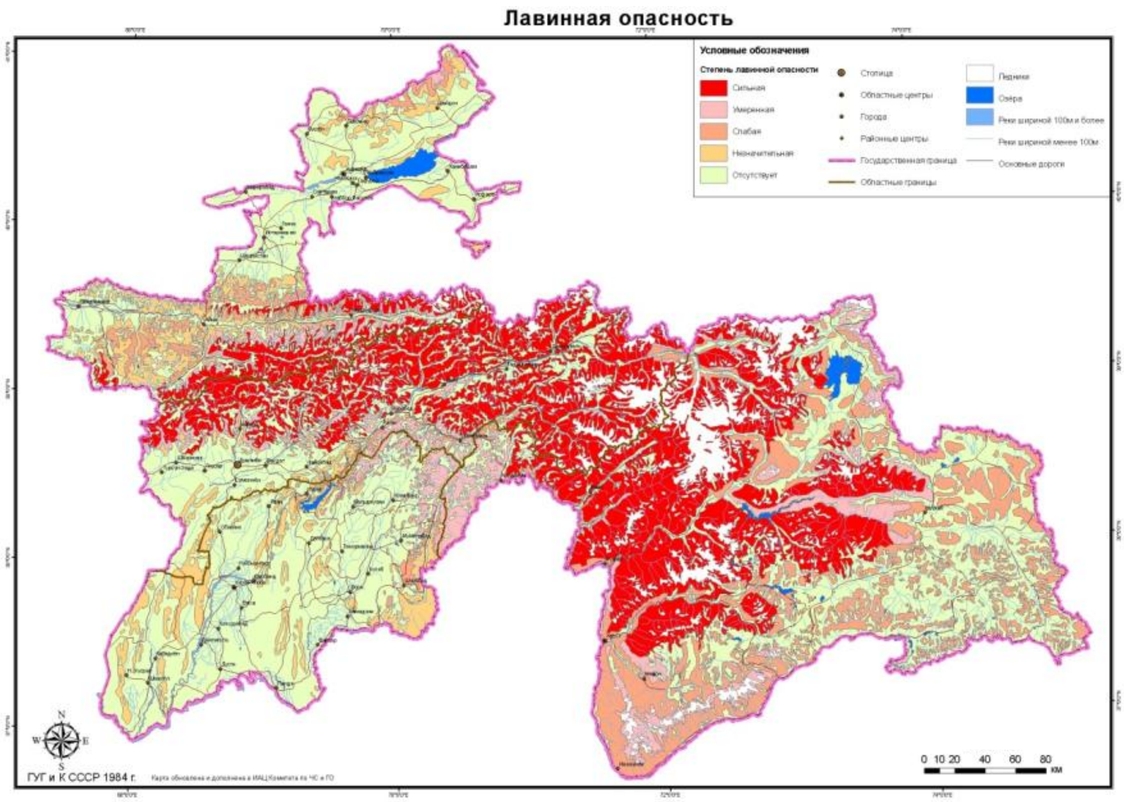

Fig. 9. Avalanche hazard map of Tajikistan.

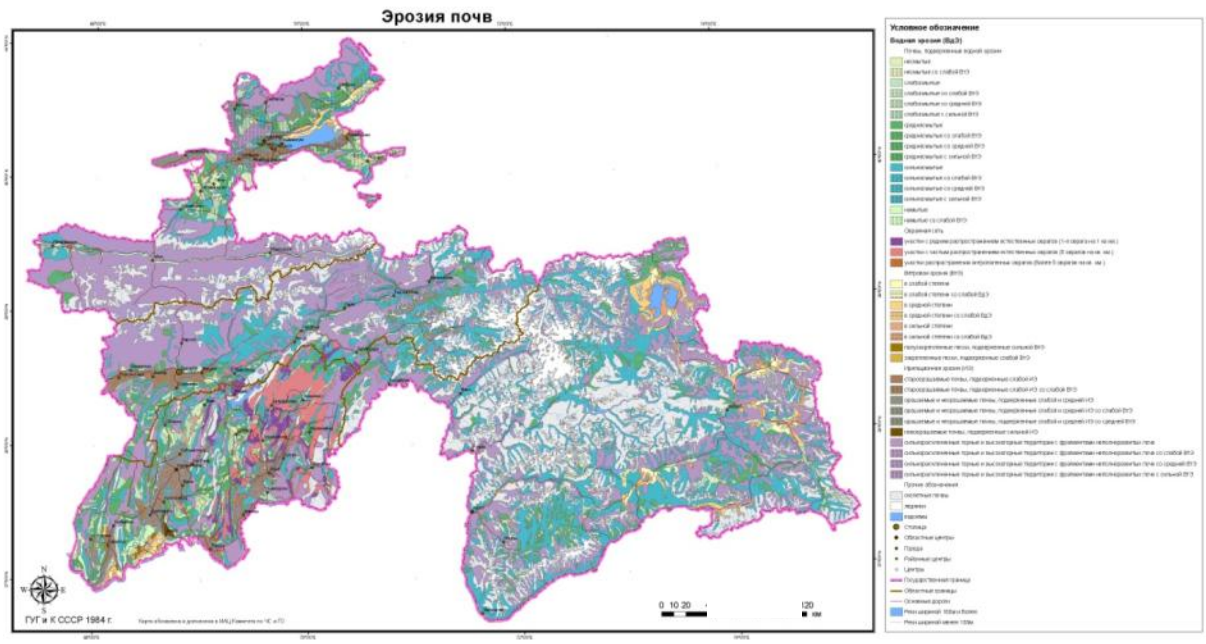

Fig. 10. Areas on the territory of Tajikistan affected by erosion processes.

5. VULNERABILITY ASSESSMENT OF TERRITORIES, POPULATION AND INDIVIDUAL FACILITIES

Vulnerability assessment with regard to natural hazards is done based on their predicted intensity in the surveyed territories of agricultural, specialized and other designation (hereinafter “territories”), individual populated areas, groups of buildings and structures within their boundaries, engineering, transportation and social infrastructure facilities (hereinafter “facilities”), undeveloped areas of cultural and business, industrial and recreational designation, and also with regard to population staying within the above listed risk receptors on a relatively regular or intermittent basis.

Vulnerability of risk receptors to natural hazards of a certain genesis and intensity should be established based on assessment of actual (ex post) economic vulnerability of similar or such-like risk receptors after devastating effects of similar intensity and/or based on calculations of virtual deformations of the assessed facilities exceeding the maximum permissible ratings set in the construction documents using the general formula:

$$V_e(H) = D_d(H) / D_c = \sum_{i=1}^{i=n} (N_i / N) \cdot K_{ei} \tag{1}$$

where $V_e(H)$ is the facility’s economic vulnerability to hazard H of a certain genesis and intensity (in unit fractions); $D_d(H)$ is the possible damage with due regard for losses from impacts of dangerous natural phenomena and expenses required to compensate for effects of those impacts (in somonis, USD, RUR); D_c is the facility cost before the impact (in somonis, USD, RUR); -N_i - dimensions (volume, area or length) of the damaged portion of the i-element within the facility; N - original dimensions of the i-element; K_{ei} - a quotient factoring in the specific damage cost resulting from destruction of an individual portion of the facility against the total losses from the accident; n - the number of individual elements within the facility. All cost values should be reduced to a single time period.

It is recommended that vulnerability of operated facilities to natural hazard H should be determined with due regard for the physical wear of those facilities as of the assessment date using the following formula:

$$\mathbf{V_c(H) = V_e(H) + W_s,} \tag{2}$$

Where $V_c(H)$ represents economic vulnerability of the operated facility to the H hazard; V_e - initial econimic vulnerability of the facility to the H hazard derived net of its wear using the formula (1); W_s - physical wear of the facility determined by formulas:

$$W_c = \sum_{i=1}^{i=m} (P_i / P_c) W_i \tag{3}$$

$$W_s = \sum_{i=1}^{i=n} W_c \cdot K_{ci} \tag{4}$$

where W_c represents physical wear of an element or system within the facility determined in unit fractions based on its examination in accordance with regulatory and procedural guidelines; P_i - dimensions (area or length) of the damaged portion of the element or system; P_c - original dimensions of the element or system; m - number of damaged portions; K_{ci} - quotient corresponding to the share of replacement cost of the individual element in the overall replacement cost of the facility determined in unit fractions; n - number of individual elements or systems within the facility.

If there are no wear charts for the facilities the wear may be determined based on actual examination data of those facilities in line with the same criteria.

Vulnerability of buildings and structures to individual hazardous phenomena caused by actualization of geological hazards (in case there no reliable actual data for similar facilities and no calculations of their deformations are available) may be determined using the following formula:

$$\mathbf{V_e(H) = V_{ei}(H) \cdot S_d(H) / S_f + W_s} \tag{5}$$

where $V_{ei}(H)$ represents vulnerability of a portion of the facility to the hazard H of certain intensity (damage area); $S_d(H)$ - area within the facility affected by the hazard H (m^2); S_f – total area of the facility (m^2); W_s - physical wear of the facility.

Vulnerability of facilities to landslide, landslip and rockslide processes should be taken equal to one if the gravitation strain surface lies below the basis of the assessed facility. In all other cases vulnerability to landslides should be determined based on the formula (1).

Vulnerability of facilities to seismic impact should be determined based on the damage classification depending on intensity of seismic impact in accordance with the seismic intensity scale MSK-64 (developed by S.V.Medvedev, V. Sponheuer and V.Karnick).

It is recommended that vulnerability of individual parts of buildings and structures affected by gully and marginal erosion be taken equal to one; whereas the overall vulnerability of such facilities should be determined with due regard for their exposure to the assessed hazards in accordance with the formula (1).

Vulnerability of territories to the natural hazard H of a certain genesis and intensity should be assessed in physical and economic terms using the following formulas:

$$V_{tf}(H) = S_d(H) / S, \quad (6)$$

$$V_{te}(H) = D_{td} / D_{te} = V_{tf} \cdot K_t, \quad (7)$$

where $V_{tf}(H)$ and $V_{te}(H)$ represent respectively physical and economic vulnerability of the territory to the hazard H (in unit fractions); $S_d(H)$ - affected area within the territory in case of sporadic manifestation of the hazard H (m^2, hectares, km^2); S - area under assessment (m^2, hectares, km^2); D_{td} - value of the affected portion of the territory (somonis, USD, RUR.); D_{te} - total value of the territory under assessment (somonis, USD, RUR); K_t - quotient characterizing the share of the affected area in the total value of the territory.

The value of land plots is determined in accordance with their cadastral value; and in case no such value is available, based on the cost of agricultural products produced on the territory over 5 years with due regard for its cropping capacity.

Social vulnerability of population to the natural hazard H should be determined assuming the possibility that people may be affected by negative events similar to the ones that occurred in Tajikistan and other countries of the world (with resembling natural conditions) using the following general formula:

$$V_s(H) = P_d / P_t = V_t(H) \cdot V_{st}(H) \cdot V_{ss}(H), \quad (8)$$

where $V_s(H)$ - is an indicator of social vulnerability - the share of affected persons as a result of a natural disaster striking the facility; $P_d(H)$ - number of persons who would lose their lives as a result of actualization of the hazard H (number of persons); P_t - overall number of people staying in the affected area (number of persons); $V_t(H)$ - physical vulnerability of the territory or economic vulnerability of the facility to the hazard H determined in accordance with the following formulas respectively (6), (2) or (1) (unit fractions); $V_{st}(H)$ - social vulnerability of population in time which is equal to the possibility of a person happening to be within the facilities or undeveloped areas at the time when they are affected by the hazard H (unit fractions); $V_{ss}(H)$ social vulnerability of population in space which is equal to the possibility of a person being killed in the facility affected by the hazard H (unit fractions).

Population vulnerability in time to the hazard H should be assessed based on factual data regarding duration time when people of different ages and professional background stayed in the affected facility or in a similar facility using the following formula:

$$V_{st}(H) = t_d \cdot t_y / 24 \cdot 365, \quad (9)$$

where t_d and t_y represent average duration for which a typical person can stay in an affected facility with due regard for the season and time of the day (hours, days).

In assessing vulnerability of population to quick on-set natural hazards resulting in fast (in a matter of minutes, hours or first few days) demolition of facilities it is recommended to use data on physical, economic and social losses caused by effects of genetically different natural hazards on facilities structurally or functionally similar to the ones under assessment. Should such data be unavailable, social vulnerability of population within facilities may be established at the time when feasibility studies for any decisions are prepared regarding activities aimed at prevention of natural disasters.

6. QUANTITATIVE RISK ASSESSMENT

6.1. Calculation of physical and economic risks

It is recommended that assessment of geological risks is done in a consistent manner for individual territories, facilities and their systems with similar natural conditions, nature of development and existing natural hazards with a lead period (time for which the likelihood of adverse natural emergencies is assessed) equal to the effective period of documentation regulating development or use of the assessed territories or the set working life of facilities or their systems without complete overhaul but for no longer than 50 years because of cardinal changes that may affect both the assessed hazards and facilities in a longer run.

At all stages of documentation design and also in development of activities aimed at prevention of emergencies of natural origin, one should use, by way of final assessment ratios, overall and specific values of differentiated (by individual processes) and integrated (aggregate of all processes) economic and social risks of losses as a result of natural hazards, reduced to 1 year.

Differentiated economic risk of losses from seismic impacts, landslides, rockslides, mudflows, soil subsidence caused by the processes of water-logging, sagging, liquefaction and scouring of soil, as well as from other quick on-set natural hazards forming in a matter of seconds, minutes and first days, should be assessed in the form of complete and specific (reduced to a unit of area) risk values by the following formulas:

$$\mathbf{R_e(H) = P^*(H) \cdot P_s(H) \cdot V_c(H) \cdot D_e,} \qquad (10)$$

$$\mathbf{R_{se}(H) = R_e(H) / S_o,} \qquad (11)$$

where $R_e(H)$ and $R_{se}(H)$ represent respectively complete (somonis/year) and specific (som/m^2/year, som/ha/year, som/km^2/year) risk of loss from the hazard H of a certain genesis and intensity; P*(H) - recurrence of the hazard H within a certain area numerically equal to its statistical probability (events/year); $\mathbf{P_s(H) = S_o/S_t}$ - geometrical probability that the assessed territory or facility will be spacially affected by the hazard H; S_o - area of the territory or facility (m^2, hectares, km^2); S_t - area within which the hazard H may be manifested (m^2, hectares, km^2); $V_e(H)$ - economic vulnerability of the assessed facility to the hazard H determined by the formula (7) for territories and by formulas (1), (2) or (5) - for facilities; S_o - area of the facility (m^2, hectares, km^2); D_e - facility cost before it is affected (som.).

If the area of the assessed facility corresponds to that of the territory on which the hazard H may be manifested, than $P_s(H)$ in the formula (10) is equal to 1.

Complete differentiated risk of economic loss from erosion processes, ravine erosion and other permanent natural hazards characterized by a relatively continuous development in time and space should be determined largely based on the speed with which those hazards may affect the assessed facilities using the formula:

$$\mathbf{R_e(H) = W \cdot P(W_h) \cdot V_e(H) \cdot d_e,} \quad (12)$$

where W represents speed with which the assessed facility may be affected by the hazard H of a certain intensity (m^2/year, ha/year, km^2/year); $P(W_h)$·- likelihood of actualization of the speed; $V_e(H)$ - economic vulnerability of the facility; d_e - facility value reduced to a unit of its area (specific cost of fixed assets, som./m^2, som./ha, som./km^2).

Complete differentiated risk from slow sagging and upheaval of the land surface associated with soil subsidence should be determined using the formula

$$\mathbf{R_e(H) = P(H) \cdot V_e(H) \cdot D_e \cdot T_c} \quad (14)$$

where P(H) represents possibility of a deformation of a certain amplitude occurring at the end of the facility's service life; $V_e(H)$ - economic vulnerability of the assessed facility to that deformation determined by analogy; D_e - facility cost before it is affected by the process (somonis); T_c - service life of the facility (years).

Specific values of differentiated risk of economic loss from permanent hazards described above should be determined by the formula (11). When assessing the risk from those hazards using formulas (12) and (14) it is recommended that average process on-set speeds and average deformation amplitudes be used whereas the likelihood of the hazards' actualization during the service life of the facility should be taken equal to one.

In assessment of natural risk of economic loss for territories and facilities of a certain historical or architectural value it is recommended that in the formulas (10) – (14) the cost of those facilities before an impact by one or several hazards should be substituted by their reconstruction cost.

In assessment of differentiated economic risk of loss for territories and facilities it is necessary to assess and factor in natural risks emerging on adjacent territories as a result of actualization of remote hazards.

Differentiated and integrated risks of loss from multiple manifestations of an individual natural hazard of a certain genesis (type) with different intensities within the assessed territory or economic facility and those from an aggregate of quick on-set and permanent hazards of any genesis, intensity and recurrence, affecting the facility either concurrently or discretely in time and space, may be determined (in view of their low values) as a sum of differentiated risks from those hazards calculated by the formulas (10) – (14).

6.2. Social risk assessment

Natural risk of social losses of population on the territory of Tajikistan should be assessed for quick on-set natural hazards manifested in the form of earthquakes, rapid slope displacements (landslides, rockslides, mudflows, avalanches) and floods resulting in destruction of territories and facilities, motorways and railways, loss of life and injuries among population staying within the above listed or other facilities.

Differentiated social risk from quick on-set natural hazards should be determined in the form of individual and complete values of possible loss of human lives based on the following formulas:

$$\mathbf{R_i(H) = P^{*} \cdot V_s(H),} \qquad (15)$$

$$\mathbf{R_s(H) = R_i(H) \cdot D_p,} \qquad (16)$$

Where $R_i(H)$ represents individual risk to die from the hazard H numerically equal to the likelihood of such an event happening to one person in a group staying within the assessed facility (pers/pers-year); P*(H) - recurrence of the hazard H (events/year); $V_s(H)$ - social vulnerability of population to the hazard H determined using the formulas (8) and (9) or based on Annex 5; $R_s(H)$ - complete social risk of dying from the hazard H equal to the number of fatal cases caused by the hazard within a year (pers/year); D_p - total number of population within the assessed territory or facility (pers.).

Integrated social and individual risk of life loss as a result of several quick on-set natural hazards affecting the assessed facility should be determined by summing up corresponding differentiated risks of life loss calculated using the formulas (15) and (16).

Assessment of social and individual risk of life loss is mandatory when doing feasibility study of activities aimed at prevention of emergencies of natural origin.

7. IMPLEMENTATION PROCEDURES OF THE DISASTER RISK ASSESSMENT METHODOLOGY USING GIS

7.1. Source data requirements

Structuring of digital cartographic information, its organization by thematic coverages (layers) in development of digital cartographic materials for the purpose of disaster risk assessment should be done with due regard for the set objectives. Structuring of digital spacial information and its organization by thematic coverages (layers) within electronic cartographic materials must provide:

- mathematical framework for cartographic presentation of data;
- electronic-cartographic presentation and georeferencing of territorial units constituting the basis of the undertaken risk assessments;
- electronic-cartographic presentation and georeferencing of natural features, including water bodies, relief features, manifestations of dangerous natural phenomena entered on digital maps (in accordance with their scale and conditions as of the time of compilation/actualization) and also representing analysis objects;
- electronic-cartographic presentation and georeferencing of risk-receptor technological facilities located in an area which can be potentially affected by natural hazards entered on digital maps (in accordance with their scale and conditions as of the time of compilation/actualization), including technological facilities affected by dangerous geological processes.

Spacial information contained in source digital maps must be represented (contained) in the following packages of layers (coverages):

- mathematical framework;
- relief and elements of the elevation base;
- territorial units;
- water bodies;
- geomorphological features;
- manifestations of natural hazards (seismic hazards, areas affected by dangerous slope processes (landslides, landfalls, rockslides), mudflow hazard, avalanche hazard, inundation zones during flooding, hazard associated with water-logging and erosion processes);
- forest land objects;

- industrial facilities;
- nonproduction facilities with identification of socially significant facilities;
- agricultural facilities;
- transportation network and infrastructure.

When using geoinformation systems based on linear-nodal topology (e.g. ArcGIS) the above layers (coverages) are additionally distinguished based on spacial characteristics of features - polygon, line or point.

Each electronic map should contain its specifications which should be included in the metadata description. Mandatory map specifications include:

- sheet number, name and scale;
- coordinates, elevation and numbering system;
-sheet corner coordinates in degree-based and rectangular coordinates systems and in the coordinate system used in the map;
- information about materials used in generation of the map;
- date of issue (acceptance) of the map;
- maker of the digital map;
- information regarding assemblage of the sheet with other adjacent sheets;
- date of the last update;
- quality conformance data.

Metadata should include information about the structure, composition and number of objects on the electronic map which are envisaged to be used in generation of a set of electronic risk maps.

When an electronic map is created, logically integral objects of special designation are often divided into several physically independent objects. For example, a river (logically integral object having a single name) over its length from the head to the mouth may consist of several physical objects (lake portion, riverbed portion) on the electronic map having different classification codes, different individual ID numbers and different sets of attributive semantic characteristics. However, to enable execution of various computing and statistical operations (despite all those changes) it should remain in integral object. To make sure that we can use the river in the future as an integral object with specialized software when individual objects describing the river are entered on the map we should follow the rule of spacial (metric) and logical (semantic) correlation.

Spacial correlation between adjacent (contiguous) objects must be ensured during creation of electronic map objects. It may be achieved as follows:

- at the place of contact both the objects must have a point of absolutely identical plane (and in case of a 3-D metric also elevation) coordinates;
- both the objects should have the same digitalization direction (the end point of one object should be the start point of the other one);
- space-variant linear objects must have only one point of tangency;
- a logically continuous object within one sheet may have a physical discontinuity only in case its attribute characteristics change in the point of discontinuity (there should be no unjustified discontinuities of logically continuous objects).

Logical (semantic) harmonization of electronic map objects forming a logically integral object is achieved through the use in their attribute semantic characteristics of:

- the same object name (with due regard for the capitalization, spaces, hyphens and other special symbols);
- attribute of affiliation with a logical set of objects or reference to the main object in the set;
- object number in accordance with the single classifier of objects for a given class.

The first logical harmonization requirement (same names) should be complied with at the stage of creation of a digital map. The second and third ones may either be complied with during map creation or afterwards through application of specialized processing procedures.

Digital semantic attributive description of objects is done by using object codes, localization codes and attribute codes listed in the classifier for each type of objects and also for values and attribute value codes. This being said, attributes have a special part in digital description of objects.

Based on their purpose attributes are divided into qualitative and quantitative. This refers to attributes containing information about object properties. According to their contents attributes are subdivided into numeric and symbolic. A numeric attribute may only contain a single digit (integer or real number, positive or negative). For numeric attributes (apart from those presented in a symbolic form) the symbol of "." is used as delimiter between the integer and fraction part. A symbolic attribute may contain any symbols.

Quantitative attributes contain quantitative values of respective objects expressed in real or integer numbers.

7.2. Use of remote-sensing data

For actualization of cartographic materials it is advisable that remote-sensing data in digital format or hard copy imagery processed in raster scanning devices be used. Satellite imagery accompanied by survey specifications, catalogues of control point coordinates, elevation matrices created by photogrammetric measurements or developed based on maps of different scales meeting the accuracy requirements adopted for the electronic map under development should be used as the main source materials. By way of auxiliary source materials it is possible to use various cartographic and reference data that may facilitate interpretation of imagery and identification of objects on the electronic map.

Source materials for creation of the digital base must comply with the following requirements:

- each image must have at least 5 reference points evenly distributed over the image area (one point in every corner and one in the center).
- image should be uniform and have no defects;
- brightness, contrast and resolution of the image must allow for an unambiguous interpretation of the terrain features which should be entered into the electronic map;
- original interpretation data (if previously interpreted imagery should be used) must be based on uniform original hues and image density.

7.3. Processing of digital mapping data in risk analysis

Processing of electronic cartographic data and spacial analysis for the purpose of assessment of natural hazards and risks on the territory Tajikistan should be carried out in accordance with the requirements set forth in Section 6. A general chart of spacial analysis for the purpose of assessment of natural hazards and risks on the territory Tajikistan is shown in Fig. 5. The flow chart of preparing source electronic cartographic materials characterizing spacial distribution of natural hazards is shown in Figure 5. The flow chart of preparing source electronic cartographic materials characterizing risk-receptor objects is shown in Figure 7.

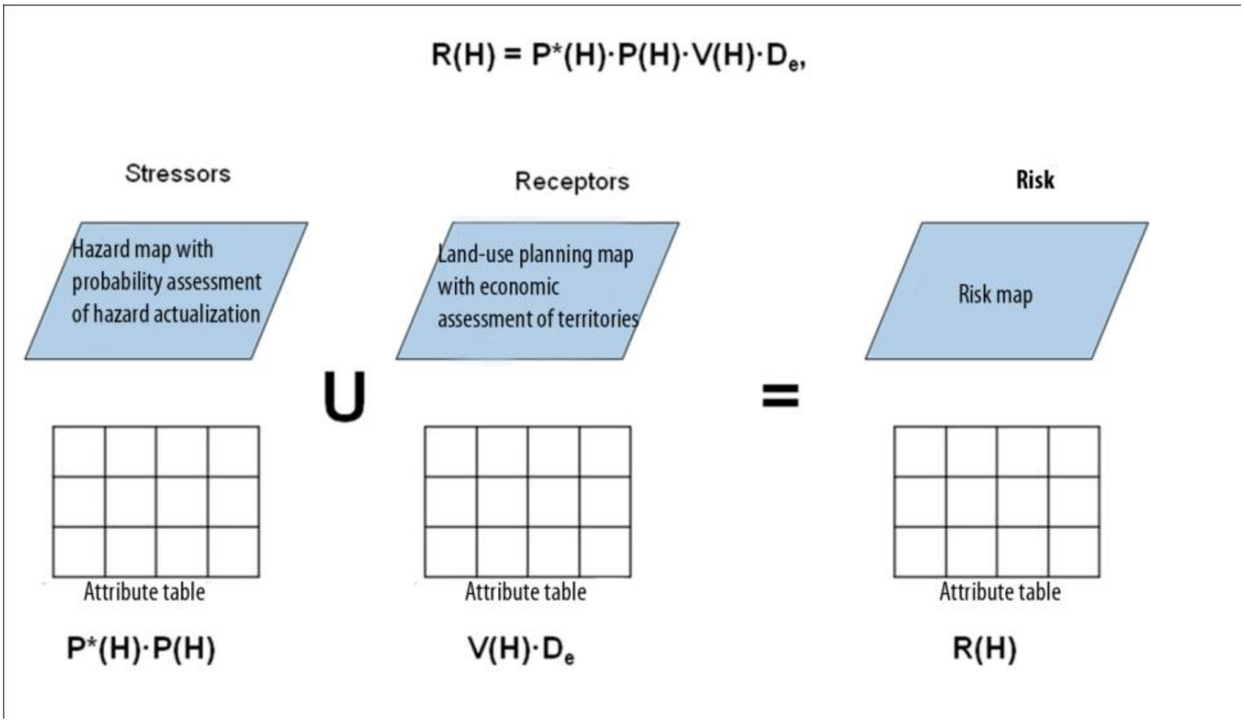

Fig.5. A general chart of spacial analysis for the purpose of assessment of natural hazards and risks on the territory Tajikistan.

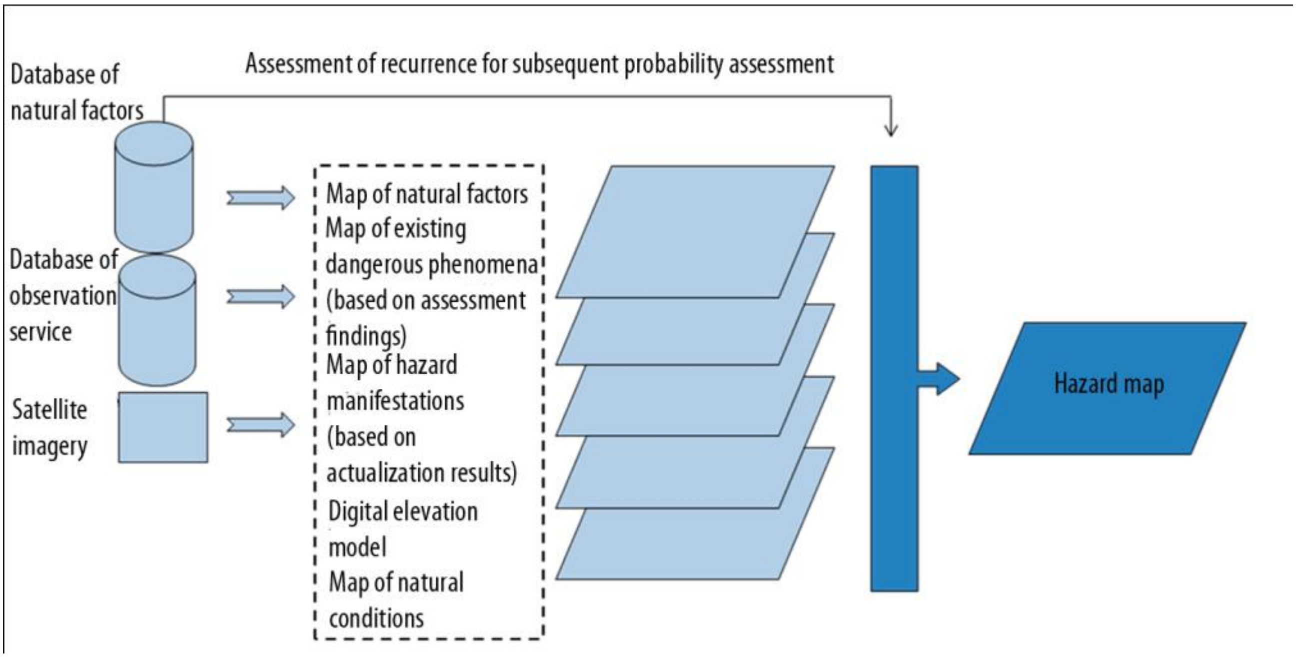

Fig.6. The flow chart of preparing source electronic cartographic materials characterizing spacial distribution of natural hazards.

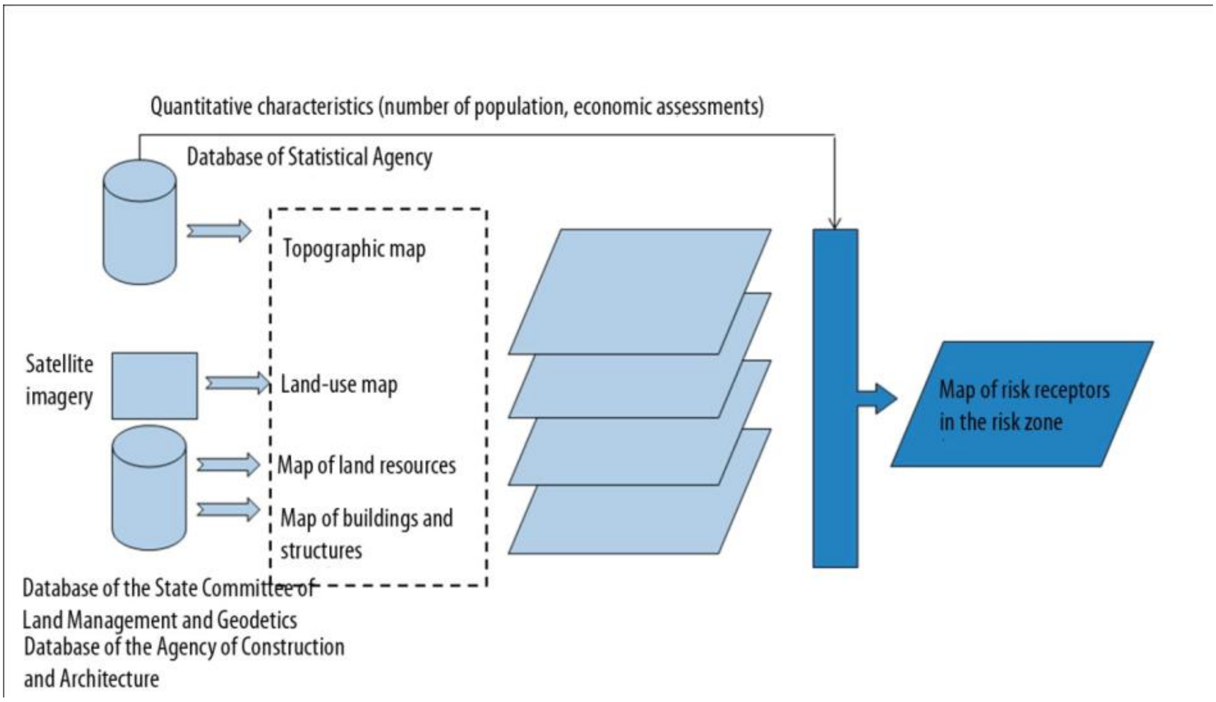

Fig.7. The flow chart of preparing source electronic cartographic materials characterizing risk-receptor objects.

7.4. Deliverables: formating requirements

To provide justification for disaster reduction activities as part of documentation, feasibility studies for construction and development of major territories, the main findings of geological risk assessment must be presented in the form of respective maps of differentiated and integrated specific economic and individual risks of losses within the assessed territory or facility and on adjacent territories, as appropriate.

Results of cartographic assessment of natural risk should in all cases be substantiated by documents in the form of explanatory notes to risk maps, statements of risks, reports or chapters in appropriate sections of project documentations developed in accordance with these Guidelines.

CONCLUSION

Disaster risk assessments and ranking of risks facilitates planning and implementation of risk reduction work, bringing the risk down to an acceptable level or maximum risk reduction against the base-line level. In accordance with the above objectives the theory of economic analysis in competitive business environment offers two key approaches to undertaking studies of this kind.

The first approach, “cost-benefit analysis” suggests that reduction of social and economic risk must be implemented insomuch as additional benefits from risk reduction are higher than additional costs to achieve them (and the risk level attained in this way is determined as “acceptable”).

The second approach is called “cost effectiveness evaluation”. It suggests that reduction of any social and economic risk must be achieved at the lowest possible cost. Therefore, the cost effectiveness evaluation may be used to justify priorities at the stage of land-use planning and designing of risk reduction activities (from the cheapest to the most expensive). It is the second approach that is used most widely although, firstly, it does not answer the question: to what level should risk be reduced? Secondly, the use of “cost effectiveness” approach makes it possible to avoid discussion as to what risk level can be considered acceptable and is well-suited for typical situations when a decision maker has only limited financial resources at his/her disposal and strives to achieve the maximum risk reduction under such conditions.

All future decisions aimed at achievement of the set goal (adoption of a risk-reduction action plan) are taken based on economic analysis of risk minimization alternatives. The action plan provides a justification for priority rating of those activities based on criteria of “cost efficiency per risk reduction unit”.

Therefore, economic justification of a risk reduction strategy is done on the basis of a cost efficiency analysis of activities resulting in reduction of risk. Such an analysis is needed to justify priorities in implementation of risk reduction activities and rational allocation of largely limited financial resources available for such activities. This provides the basis for the best risk reduction scenario and subsequent development of a respective action plan.

Development of a risk reduction scenario consists in assessment of risk reduction approaches, choice of an activity or a set of activities and their implementation. The cost effectiveness evaluation suggests that reduction of any risk must be achieved at the lowest possible cost.

The use of cost effectiveness analysis in risk management practice involves implementation of the following five stages:

- identification of the base-line risk levels with the existing hazard level in reliance on the completed assessments and their priority ranking;
- drawing up of a list of future projects and possible managerial decisions aimed at risk reduction; identification of risk reduction extent that can be obtained from implementation of every such activity;
- evaluation of implementation costs for each of the proposed activities;
- calculation of the marginal cost value of risk reduction within each of the activities;
- justification of priority ranking of activities based on the criteria of costs per risk reduction unit.

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ANNEXES

Annex 1.

Composition of the working group tasked with development of disaster risk assessment methodology for the territory of Tajikistan

No.	FULL NAME	Organization
1	A.M.Shomahmadov	IMAC COES
2	Saidanvar Ibragimov	Ministry of Health
3	Rizvon Delyobov Zikriyo Khomidov	State Statistical Agency
4	Khusnidin Nabiev	Ministry of Energy
5	Alovudin Anoyatshoev	Ministry of Transport and Communications
6	Sukhrob Yokubzoda	Ministry of Transport and Communications
7	Yusuf Shodiev	Agency for Civil Engineering and Architecture
8	Zarina Vahidova	Ministry of Economy and Trade
9	Lashkarhon Sohibov, Kutfullo Narzulloevich Ziyodulloev	Ministry of Agriculture
10	Abdullo Yorov	Ministry of Finance
11	Ilhom Abdunazarov	Committee for Protection of Environment
12	Rahimjon Usmanovich Juraev	Central Directorate of Geology
13	Jamilya Baidullaeva	Tajik Hydrometeorological agency
14	Mirzo Saidov	Committee for Land Management and Geodetics of RT
15	J. Nizomov F.H. Karimov A.R. Ischuk	Institute of Seismic Engineering and Seismology
16	Azim Hisoriev	Ministry of Water Resources of RT
17	J. Juraev	Barki Tojik
18	Hamidjon Oripov	Barki Tojik
19	Shahboz Shahbozovich	FAZO

Annex 2.

DISASTERS AND HAZARDS TYPICAL FOR TAJIKISTAN

(cited from the National Disaster Risk Management Strategy of the Republic of Tajikistan for 2010-2015
approved by the resolution of the Government of the Republic of Tajikistan
dated 30 March 2010 No.164)

Tajikistan is prone to the following hazards:

a) Hydrological and Meteorological:

- floods;
- droughts;
- frost and cold spells;
- snow fall;
- precipitation;
- hail;
- wind;
- avalanches;
- desertification;
- high water table.

b) Geological:

- mudflows;
- landslides;
- earthquakes;
- rockfall.

c) Biological:

- epidemics;
- epizooty;
- epiphytoty;

d) Technological:

- industrial wastes;
- hazardous biological wastes;
- inadvertent chemical releases (into air, water, soil);
- accidents on hydraulic engineering installations (i.e. on dams, dykes, irrigation systems, etc.);
- traffic incidents including those involving railway, motor vehicle, air and water transport;
- traffic incidents involving transportation of hazardous cargos;
- accidents associated with gas, fuel and trace heating;
- accidents associated with utility systems.

Annex 3.

CLASSIFICATION OF EMERGENCIES FOR TAJIKISTAN

(adopted through a decision of the collegium of the Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan No.4 dated 10/10/2007)

Types of emergency situations

Classification code	**Type of Emergency***	**Relevancy Criteria****			
		Losses			**Prevalence**
		Persons affected	Persons whose livelihoods were disrupted	Scope of inflicted material damage (on the day of the event)	Affected area*** in reference to territorial boundaries of facilities and administrative units
1	on-site	<10	< 100	< 1,000 minimal monthly wages	Contained within the confines of an industrial or social facility
2	local	10-:-50	100-:-300	1,000-:-5,000 minimal monthly wages	Contained within the confines of a village or jamoat
3	territorial	50-:-500	300-:-500	5,000-:-500,000 minimal monthly wages	Contained within the confines of a town or district
4	provincial	50-:-500	500-:-1,000	500,000-:-1,000,000 minimal monthly wages	Contained within the confines of a province
5	nation-wide	> 500	> 1,000	> 1,000,000 minimal monthly wages	Affects more than one provinces or three or more districts of republican subordination
6	transboundary			Effects of emergency losses go beyond the country's boundaries.	Effects of emergency losses go beyond the country's boundaries or an emergency occurs outside the country and its effects spread to the territory of Tajikistan
**Types of emergencies are listed in accordance with the Resolution of the Government of RT No.367 dated 1 August 2006 "On classification of emergency situations"					
**If at least one of the parameters exceeds the loss or distribution characteristics for a given type of emergency than the emergency is upgraded to the next category and, respectively, if at least one parameter is less than the loss or distribution characteristics for a given emergency type the emergency is downgraded to a lesser type.					
***Impact zone refers to the boundaries of facilities or individual territorial units a country or countries where direct physical losses were recorded.					

Types of emergency situations
(by the example of emergencies of the natural subtype)

Type classification code	Subtype classification code	Classification code of an emergency type	Emergency type	Organization responsible for monitoring and forecasting
1-:-6	1	1	Earthquakes	
1-:-6	1	2	Dangerous geological phenomena	
1-:-6	1	3	Dangerous meteorological phenomena	
1-:-6	1	4	Dangerous hydrological phenomena	
1-:-6	1	5	Wildland fires	

Subtypes of emergency situations

Type classification code	Subtype classification code	Classification code of an emergency type	Classification code of an emergency subtype	Emergency subtype	Definition and criterion
1	**2**	**3**	**4**	**5**	**6**
1-:-6	1	1	1	Earthquakes	Earthquake with the intensity of 6 or more.
dangerous geological phenomena					
1-:-6	1	2	1	Landslides, rockslides, screes	Death toll - 2 and more persons Number of affected person - 4 and more persons Disturbance of soil cover over the area of 10 and more hectares with damage inflicted on population and facilities of the national economy. Simultaneous loss of agricultural crops or natural vegetation on the area of 100 hectares and more.
1-:-6	1	2	2	Karst subsidence (cave in) of land surface, subsidence of loess rock	Death toll - 2 and more persons Number of affected person - 4 and more persons Disturbance of soil cover over the area of 10 and more hectares with damage inflicted on population and facilities of the national economy. Simultaneous loss of agricultural crops or natural vegetation on the

					area of 100 hectares and more.

1	2	3	4	5	6
1-:-6	1	2	3	Erosion, slope wash	Death toll - 2 and more persons Number of affected person - 4 and more persons Disturbance of soil cover over the area of 10 and more hectares with damage inflicted on population and facilities of the national economy. Simultaneous loss of agricultural crops or natural vegetation on the area of 100 hectares and more.
1-:-6	1	2	4	Mudflow	Impetuous torrent of characterized by a high destructive strength which consists of a mix of water, sand and rock and forms unexpectedly in mountain river basins as a result of heavy rains or intensive melting of snow.
1-:-6	1	2	5	Water logging (water table rise)	Anomalous water table rise causing damage or collapse of buildings and structures, destruction and loss of agricultural crops.
dangerous meteorological phenomena					
1-:-6	1	3	1	High wind, including squall, whirlwind	Wind velocity (including gusts) - 25 m/sec and more Wind having lower velocity which has caused significant damage.
1-:-6	1	3	2	Heavy rain (sleet, freezing rain)	The amount of precipitation - 30 mm and more over 12 or less hours. Intensive rains with lesser amount of precipitation which caused significant damage.
1-:-6	1	3	4	Prolonged heavy rains	The amount of precipitation - 60 mm and more falling over 12 or more but less less than 48 hours. Intensive rains with lesser amount of precipitation which caused significant damage.
1-:-6	1	3	5	Heavy snowfall	The amount of precipitation - 20 mm and more over 12 or less hours.
1-:-6	1	3	6	Prolonged heavy snowfall	The amount of precipitation - 40 mm and more falling over 12 or more but less less than 48 hours. Intensive snowfall with lesser amount of precipitation which caused significant damage.
1-:-6	1	3	7	Hail	Hailstone diameter - 20mm and more; or hail with lesser diameter of hailstones which caused extensive damage

1	2	3	4	5	6
1-:-6	1	3	8	Blizzard	General or ground blizzard with the average wind velocity of 15 m/sec and more lasting for 12 hours and more.
1-:-6	1	3	9	Strong dust-storm (sandstorm)	Duration - 6 hours; wind velocity - 15 m/sec., decrease of visibility to 100m and less.
1-:-6	1	3	10	Strong black frost, sleet formation or complex precipitate, strong hoarfrost	For black frost - thickness of 20 mm and more. For complex precipitate and sleet formation - 35 mm and more. For hoarfrost - 50 mm and more.
1-:-6	1	3	11	Heavy fog	Visibility of 50m and less for 6 hours and more.
			12	Strong frost	Air temperature in the valley zone (elevated less than 1,000m above the sea level) -35^{0}C for 5 or more nights.
1-:-6	1	3	13	High heat	Maximum air temperature - no less than 40^{0}C for 5 days or more.
1-:-6	1	3	14	Ground frost	Drop in air or ground surface temperature below 0^{0}C during the vegetation period.
1-:-6	1	3	15	Drought, dry hot wind	Soil drought - productive water storage in soil - 10mm and less for twenty consecutive days. Atmospheric drought - lack of effective precipitation (more than 5 mm) during the vegetation period for 30 consecutive days or more with the maximum air temperature of 30^{0}C and more. Dry hot wind - persistence of the air temperature of 30^{0}C and more for 3-5 days with the wind of 5m/sec and low relative air humidity of 30% and less.
1-:-6	1	3	16	Snow avalanches	Any manifestations resulting in significant damage to infrastructure facilities Death toll - 2 and more persons Number of affected person - 4 and more persons

1	2	3	4	5	6
dangerous hydrological phenomena					
1-:-6	1	4	1	High water level (spring flood, ice jam, ice gorge, flash flood, flooding)	Any manifestations that may result in inundation of downstream parts of cities and populated areas, agricultural crops, highways or destruction of major industrial or transportation facilities.
1-:-6	1	4	2	Low water levels (low water period)	Persistence of water level beneath the design level of head structures for at least 10 days.

Annex 4.

REQUIREMENTS

as to the standard contents of a digital cartographic model (DCM) comprising a set of electronic maps developed based on research into development and propagation conditions of geological processes (in the form of shape files).

1. Bedrock complexes:

name: geol_a

file type: polygon;

attribute table should contain the following information (in the form of separate columns):

Column name	Contents	Format (number of symbols)
L_code	deposit age code	numeric (6)
L_text	age index	text
Idf_code	deposit composition code	numeric (6)
Idf_text	description of deposit composition	text

2. Geological boundaries:

name: geol_l

file type: linear;

attribute table should contain the following information:

Column name	Contents	Format
L_code	boundary type code	numeric (6)
L_text	description	text

3. Complexes of quaternary sediments:

name: quart_a

file type: polygon;

attribute table should contain the following information:

Column name	Contents	Format
L_code	deposit age code	numeric (6)
L_text	age index	text
Idf_code	deposit composition code	numeric (6)

Idf_text	description of deposit composition	text

4. Boundaries of quaternary sediments:

name: quart_l;

file type: linear;

attribute table should contain the following information:

Column name	Contents	Format
L_code	boundary type code	numeric (6)
L_text	description	text

5. Manifestations of geological processes shown on the map as areal objects:

name: egp_a

file type: polygon;

attribute table should contain the following information:

Column name	Contents	Format
Eg1_code	process class code	numeric (6)
Eg1_text	process class description (gravitational, seismo-gravitational, etc)	text
Eg2_code	process type code	numeric (6)
Eg2_text	process type description (deep, surface, etc)	text
Eg3_code	displacement volume, in mil. m^3	numeric (4.4.)
Eg4_code	affected area, in thou. m^2	numeric (6.2.)
Eg5_code	activity type code	numeric (6)
Eg5_text	description of activity/ maturity	text
Eg6_code	hazard type code	numeric (6)
Eg6_text	hazard class description	text
Eg_data	date of formation	text
Hyd_code	water content code	numeric (6)
Hyd_text	water content description	text
Repeat	recurrence of active periods (1/period)	numeric (6)

6. Tectonic features:

name: tect_l

file type: linear;

attribute table should contain the following information:

Column name	Contents	Format
L_code	type code	numeric (6)
L_text	description	text

7. Manifestations of geological processes shown on the map as linear objects:

name: egp_l

file type: linear;

attribute table should contain the following information:

Column name	Contents	Format
Eg1_code	process class code	numeric (6)
Eg1_text	process class description	text
Eg2_code	process type code	numeric (6)
Eg2_text	process type description	text
Eg3_code	displacement volume, in mil. m^3	numeric (4.4.)
Eg4_code	affected area, in thou. m^2	numeric (6.2.)
Eg5_code	activity type code	numeric (6)
Eg5_text	activity description	text
Eg6_code	hazard type code	numeric (6)
Eg6_text	hazard class description	text
Eg_data	date of formation	text
Repeat	recurrence of active periods (1/period)	numeric (6)

8. Manifestations of geological processes shown on the map as point objects:

name: egp_p

file type: point file;

attribute table should contain the following information:

Column name	Contents	Format
Eg1_code	process class code	numeric (6)
Eg1_text	process class description (gravitational, seismo-gravitational, etc)	text
Eg2_code	process type code	numeric (6)
Eg2_text	process type description (deep, surface, etc)	text
Eg3_code	displacement volume, in mil. m^3	numeric (4.4.)
Eg4_code	affected area, in thou. m^2	numeric (6.2.)
Eg5_code	activity type code	numeric (6)
Eg5_text	description of activity/ maturity	text
Eg6_code	hazard type code	numeric (6)
Eg6_text	hazard class description	text
Eg_data	date of formation	text
Hyd_code	water content code	numeric (6)
Hyd_text	water content description	text
Repeat	recurrence of active periods (1/period)	numeric (6)

9. Auxiliary information characterizing manifestations of geological processes shown on the map as linear objects:

name: egp1_l

file type: linear;

attribute table should contain the following information:

Column name	Contents	Format
L_code	object type code (boundary, displacement direction, etc)	numeric (6)
L_text	description	text

Annex 5.

CORRELATION

between vulnerability of weak buildings and structures and exposure of population in such facilities by types of geological and other natural and man-induced hazards
(cited from "recommendations on geological risk assessment for the territory of Moscow, 2002)

Vulnerability of buildings and structures	Vulnerability of population inside buildings and structures with different number of storeys[1)]
	1 - 4
0.005	0.000006 - 0.0001
0.05	0.00006 - 0.001
0.1	0.0003 - 0.07
0.2	0.0006 - 0.15
0.3	0.003 - 0.25
0.4	0.0052 - 0.35
0.5	0.015 - 0.45
0.6	0.031 - 0.55
0.7	0.047 - 0.65
0.8	0.064 - 0.75
0.9	0.42 - 0.85
1.0	0.7 - 0.91

Note: 1. Average and mean maximum values.