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UNDP
Tajikistan

United Nations Development Programme
Disaster Risk Management Programme
(UNDP DRMP)

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GUIDELINES

For Region-level Disaster Risk Assessment for Tajikistan

Version 4.0

Note

This version of the Guidelines has been edited to improve readability in English and clarify the procedures set out herein. The modifications made are based on comments provided through a review of the original ***Guidelines*** *by international experts conduced under the auspices of the Disaster Risk Management Program, UNDP Tajikistan.*

Dushanbe, 2014

1 Contents

2 REVISION HISTORY

This document is under version control

Version No	Reason for Update	Date Issued
1.0	First draft	17 December 2010
2.0	Second draft	12 May 2011
3.0	Final	18 May 2011
4.0	Revision of English text and modifications	June 2014

The **Guidelines on Region-Level Disaster Risk Assessment for Tajikistan** was developed with funding from the Swiss Agency for Development and Cooperation under a project administered by the Disaster Risk Management Program (DRMP), UNDP Tajikistan.
The **Guidelines** were authored by O.V. Zerkal, International Consultant, with the support of A. M. Shomahmadov, Information Management and Analysis Center, Committee of Emergency Situations (IMAC CoES), E. Khuseinov (IMAC CoES), M. S. Saidov (Scientific and Research Center, State Committee for Land Management and Geodetics of Tajikistan), and N.R.Ischuk (Barki Tajik). The editing of the English version and modifications made were based on a review of the **Guidelines** by international experts through a process managed by DRMP UNDP in 2013 and 2014.

3 USE OF THE GUIDELINES

The **Guidelines** are designed to be used by Government, non-government and international organizations involved in:

- Natural risk assessment and analysis at the regional level,
- Disaster prevention and mitigation, and
- Development planning, to incorporate disaster risk reduction.

4 INTRODUCTION

4.1 Background

Tajikistan has a high exposure to natural disasters. These disasters have negative effects on communities, including the loss of lives and livelihoods, and destruction of physical assets including infrastructure, all of which hampers development. Assessing and addressing the risk of disaster is critical to limiting the impacts of disasters when they occur and reducing the risk of disasters in the future.

A number of risk assessment methodologies exist globally. Several risk assessment tools have been developed specifically for Tajikistan, including the Mission East/Caritas/Oxfam Risk Assessment Tool and a tool developed by FOCUS, among others. These risk assessment focus on the identification of risk at or below the community level and often use a combination of qualitative and quantitative methods.

At the same time, the assessment of risk at the regional (multiple kishlak, jamoat, District) level has received little attention in Tajikistan. Risk assessments at this level of detail are needed to

- Plan development activities where disaster risks are addressed, to enable a comparison of disaster risks across kishlak, jamoats and Districts,
- Identify how best to allocate limited resources to development in a way which reduces disaster risk and,
- Plan for effective disaster preparedness and response.

To address this need, the Information Management and Analytical Center (IMAC) of the Committee of Emergency Situations (CoES) and Disaster Risk Management Program (DRMP), United Nations Development Program Tajikistan, secured funding from the Swiss Government to implement a project on **Guidelines on Region-Level Disaster Risk Assessment for Tajikistan**. The project resulted in these **Guidelines for Region-level Disaster Risk Assessment for Tajikistan,** six assessment reports (http://untj.net/index.php?option=com_content&view=article&id=209&Itemid=670), software programs for use in the assessment process and in training of Government of Tajikistan officials on the risk assessment process are available from undp.tj.drmp@undp.org.

The development of the **Guidelines** involved a range of partners, including government ministries, agencies and organizations with mandated involvement in the assessment of natural hazards (Annex 1), together with REACT partners. The **Guidelines** are intended for future use as the officially approved tool for disaster risk assessment throughout the country.

4.2 Risk Assessment Objectives

The assessment of disaster risk is an essential component of the Republic of Tajikistan's National Disaster Risk Management Strategy 2010-2015, approved on 30 March 2010 by Government of Tajikistan Resolution 164.

The identification of disaster risk assessment objectives is dependent to a considerable extent on the disaster risk management stage where the risk analysis is undertaken. Overall, three stages of disaster risk management can be identified:

1. Pre-disaster assessment and risk reduction, involving feasibility studies of development plans and implementing risk reduction activities. At this stage, existing hazards and triggers are analyzed, and the potential vulnerability of populations and infrastructure to the impact of any given hazards is assessed. Together these results lead to the definition of risk. The results of this assessment lead to disaster management activities to reduce the risks identified.
2. Risk management during an emergency, focused on the analysis of trends in hazard development and analysis of the resilience of facilities and vulnerability of population due to the on-going emergency. The results of this analysis lead to recommendations on priorities for emergency actions to reduce immediate risks, taking into account available resources.
3. Risk analysis as part of disaster response and recovery operations, involving analysis of the risk to populations and infrastructure resulting from recovery efforts and the expansion of developmental efforts linked to recovery.

This methodology focuses on addressing risk analysis objectives during the first stage of disaster risk management, i.e., the prevention of disasters, sustainable development, and advanced implementation of risk reduction activities.

4.3 Objectives of risk assessment activities.

To meet the goal of disaster risk reduction before a disaster, a disaster risk assessment needs to provide decision-making government authorities:

- Unbiased information on the status of locations and current natural hazards,
- Information on the most significant risks and weaknesses identified in terms of

disaster risk reduction, and,

- Evidence-based recommendations for disaster risk reduction.

The selection of a risk assessment method should consider the

- Goal(s) of the assessment process,
- Types of hazard to be assessed,
- Nature and frequency of hazard events,
- Criteria defining acceptable levels of risk,
- Availability of information,
- Technical resources available to conduct the assessment,
- Experience and qualifications of staff tasked with the assessment, and
- Other factors.

Preliminary risk assessments can use simple qualitative and quantitative methods (e.g., questionnaires, forms, interview guides) drawing on the experience and perceptions of those at risk. Quantitative risk analysis based on physical data is more appropriate when comparing different hazards at the regional level.

Any selected risk assessment methodology should:

- Be evidence-based and suited to the hazards to be analyzed,
- Produce results which permit a better understanding of hazard impacts and identify ways to measure and reduce the risk, and,
- Replicable and verifiable.

The **Guidelines** do not determine the frequency and need for risk analysis or criteria of acceptable risk.

5 OVERVIEW OF THE BASICS OF RISK ASSESSMENT

5.1 General Overview

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 from disasters. Risk management is the systematic application of:

- Management policies,
- Procedures and methods to identify, assess, and monitor risk, and
- An exchange of information on risk to ensure losses are reduced and sustainable development strengthened.

Effective risk management requires risk analysis and assessment. Disaster risk analysis enables us to identify existing natural hazards, determine levels of risk associated with undesirable events (in terms of their frequency and consequences) and implement risk reduction measures where risks exceed acceptable levels.

Assessing risk involved three cre elements:

1. Hazard identification and assessment - specification of natural conditions, probability analysis of hazard actualization, specification of the hazard.
2. 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.
3. Quantitative risk assessment - analysis of the risk level and degree expressed in a quantitative form allowing to draw conclusions as to acceptability/ unacceptability of the risk.

(See Figure 1, below.)

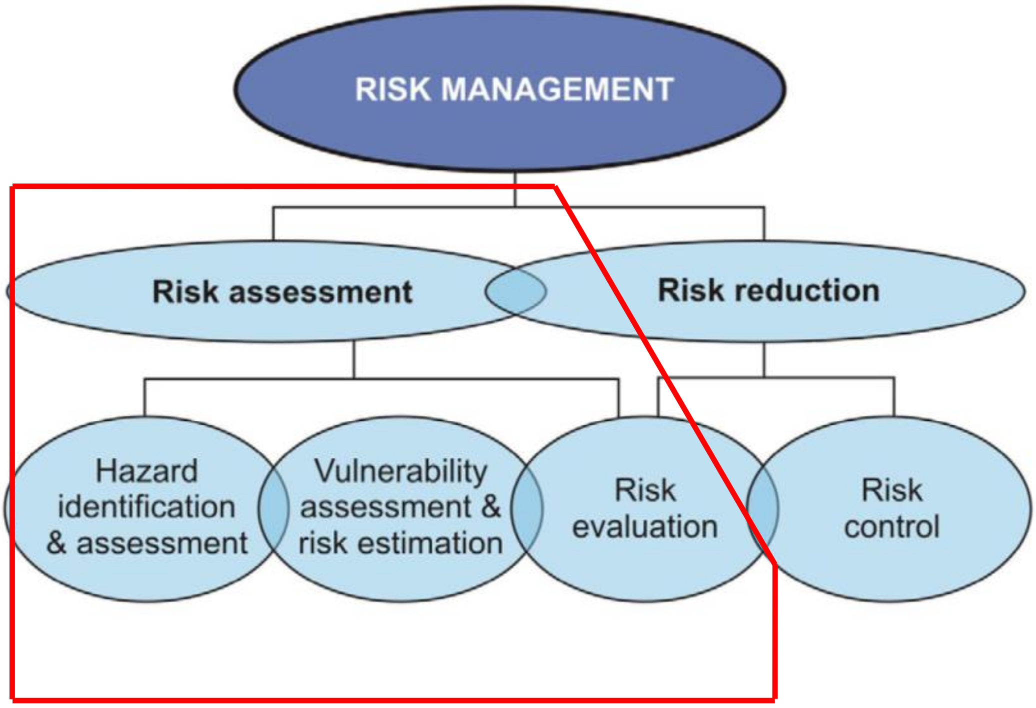

Figure 1: Risk management structure and the place (red box) of disaster risk assessment work within this structure. Based on Harris and Herbert, 1994, with additions).

Once risks have been assessed the resulting information is used to formulate and implement actions intended to reduce these risks.

Different variables can be used to assess risk:

- P*hysical risk* is the number of facilities that can potentially sustain damage during a disaster (e.g. number of households, buildings, etc) within a year.
- F*ull economic risk* is the monetary value (e.g. in Somoni, US dollars, etc.) of 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 facilities).
- *Specific economic risk* - is the monetary losses for an area unit, e.g. in Somoni or USD per m^2, per hectare or km^2.
- *Individual risk* is the probability of death of one individual in a group of a certain size within one year, e.g. 1 person in every 100,000 population within one year as a result of an emergency.
- *Social risk* is the number of persons who can potentially die/ be affected as a result of an emergency within one year (in person-years).

The level of disaster risk for a certain population, location or facility exposed to multiple hazards is determined by aggregating the value of individual risks for each hazard event (e.g. occurrence of a landslide or a mudflow, adverse meteorological conditions, etc) for a specific time period (e.g., year). The result of this calculation is referred to as the *integrated risk*.

5.2 Risk analysis and assessment definitions

Refer to UNISDR (2009) and Living with Risk (2002) for definitions of key terms used in the risk assessment process used in the **Guidelines**.

5.3 Classification of risk types

Refer to UNISDR (2009) for a discussion of the types of risk.

5.4 Key approaches and methodologies of risk analysis

{Text removed refered to other assessment tools (see References) or is covered elsewhere in the **Guidelines**.}

A disadvantage of quantitative risk analysis is its high labor and data requirements which are well justified as the method makes it possible to carry out comparative analysis of risk level based on quantitative assessment criteria for extensive territories.

5.5 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.

Sub-regional 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.

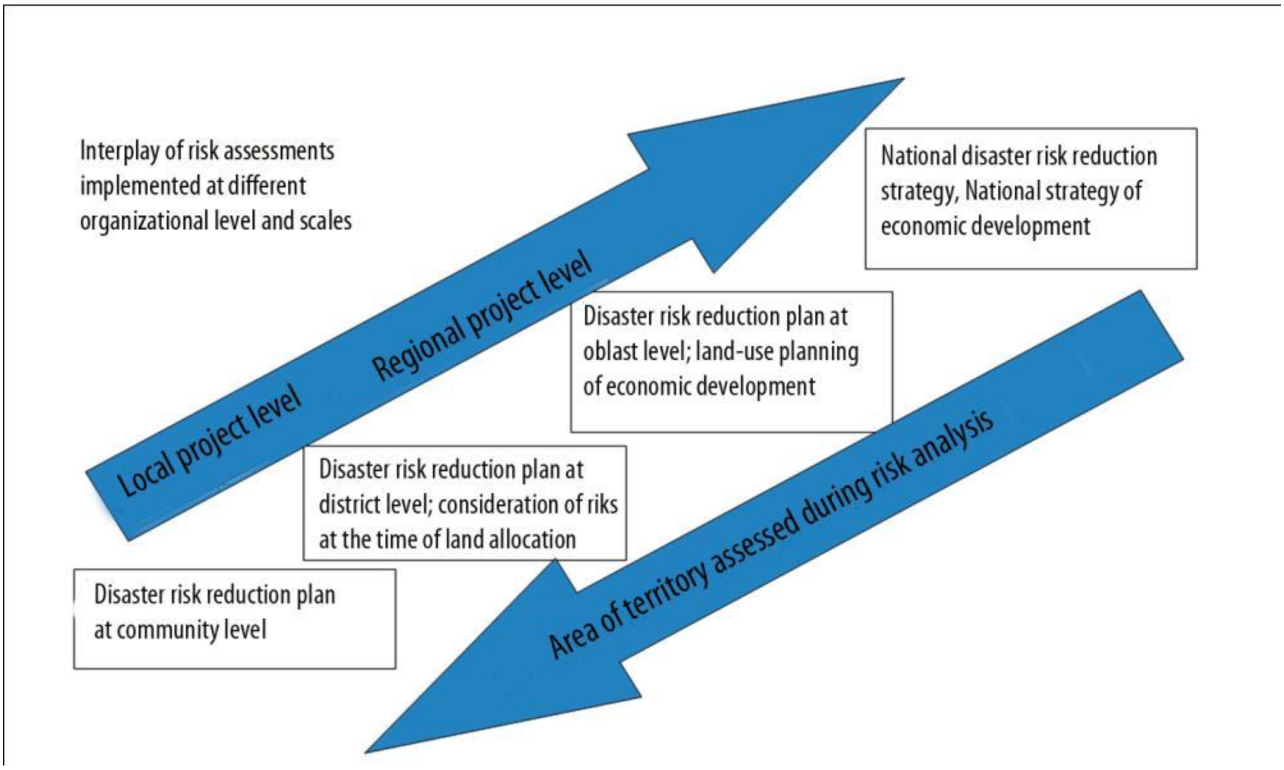

Figure 2. Interplay of risk assessment objectives addressed at different organizational levels.

6 RISK ASSESSMENT METHODOLOGY FOR NATURAL HAZARDS IN TAJIKISTAN

6.1 Main Stages and Sequence of a Risk Assessment

Assessment of risks from natural hazards is a step-by-step procedure implemented in a staged manner based on:

- Identification, review and presentation of objective natural risk constituents unaffected by human perceptions in a qualitative and, more importantly, quantitative manner, and,
- 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 assessment process are:

1. Overview of natural conditions.
2. Identification of hazards.
3. Evaluation of hazard levels
4. Identification of what can be impacted by a hazard.
5. Assessment of the vulnerability of what can be impacted by a hazard.
6. Combining hazard and vulnerability analysis and quantitative assessment to define risk.
7. Presentation of assessment results.
8. Risk monitoring.
9. Information sharing, including consultations with stakeholders
10. Training in risk assessment and risk management using assessment results.

Conditions in Tajikistan necessitate a more detailed requirement for quantitative risk assessment, including differentiated and integrated risk assessments as well as precise compliance with risk processing procedures, and assessment of the vulnerability of facilities.

The methodological approach to assessing natural risks set out in these **Guidelines** is shown in Figure 3. The general sequence chart for analysis of natural hazards and risks for Tajikistan is shown in Figure 4.

It is often extremely difficult, unfeasible or economically impractical to carry out an exhaustive risk assessment for all possible natural hazards and all possible ways the hazards may affect risk people, facilities or the economy. In such situations, a practical approach is to reduce the number of risk considered in the assessment. In this case, the analysis would comprises six stages:

1. Select the most catastrophic and/or adverse risk factors, to be considered the top-priority for the assessment.
2. Identify the typical or most likely scenarios of actualization of natural hazards linked to the selected risk factors.
3. Conduct a risk analysis for the selected scenarios using standard methods detailed above.
4. Extrapolate the results to other hazards and risks in the area being assessed.
5. Compare information on different types of risk (e.g., physical, economic, social) for different areas to identify the factor which define risk levels.
6. Combine the quantitative assessments for different types of risk to generate an overall statement of risk.

6.2 Planning and Organization of Work

The list below provides activities related to planning and management of risk assessment activities.

- Identify actions needed for a natural hazard assessment.
- Identify the natural hazards (in the location to be assessed).

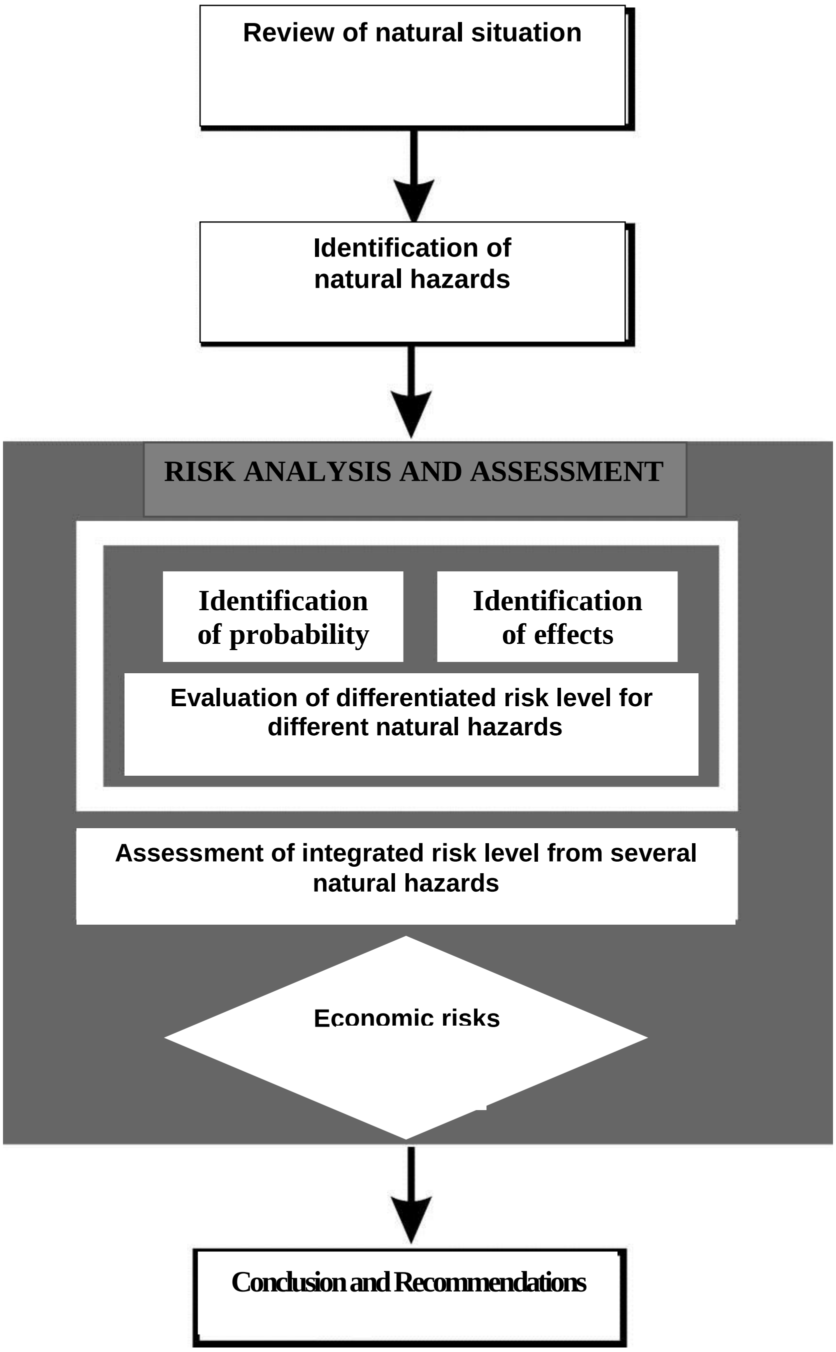

Figure 3. Consolidated methodology for implementation of natural risk assessments

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 stadiality, 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.

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?

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?

Figure 4. General Sequence Chart for the Analysis of Natural Hazards and Risks for Land Use Planning, Construction and Operation of Facilities in Tajikistan

- Undertake an analysis and assessment of elements at risk (e.g., vulnerability of population, territories and facilities), including:
    - Collection and processing of data to the level of accuracy required for the quantitative risk assessment.
    - Identification and resolving problems related to the risk assessment process.
    - Sharing of information on the risk assessment work with all stakeholders in a continuous and timely manner.
    - Quantitative assessment of natural risks.
    - Verification of assessment findings and reliability.
    - Creation of a documentation system to ensure traceability of the risk assessment activities and substantiation of risk assessment findings.

6.2.1 Discussions during the risk assessment process

Risk assessment results provide data for decision making on land-use planning and sustainable development and for the design and implementation of disaster risk reduction activities. Any results which are unclear as a result of the assessment should be addressed through participatory consultations and resolved. These consultations can formal or informal but all discussions and decisions should be properly recorded and documented.

Discussions of risk assessment-related issues may include:

- Identification and assessment of natural hazards.
- Analysis of the list of who or what is at risk, e.g., people, industrial and agricultural facilities, etc.
- How risk levels are established, including analytical methods.
- Changes to the risk data and analysis process.
- The efficiency of the risk analysis process.
- Coordination with partners and stakeholders involved in the assessment process.

Requirements for deliverables must be established during the planning for the risk assessment.

6.2.2 Planning a disaster risk assessment

A risk assessment work plan can include the following sections, with reference to appropriate secondary documentation:

- A scope of work including goals and objectives of the risk assessment and working arrangements.

- The proposed methodology of risk assessment, detailing the processes to be undertaken.
- A list of the natural hazards to be covered as part of the risk assessment.
- A list of who or what can be affected by the hazards identified.
- Responsibilities and authorities for all parties involved in the assessment.
- Arrangements for internal and external information sharing.
- A plan for discussions and consultations during the assessment.
- Documents and form for all stages of work.
- Procedures to ensure linkages with other similar projects and activities.

A risk assessment work plan should be reviewed and adjusted on a regular basis to reflect actual progress in the implementation of the assessment.

6.3 Risk Assessment Task Allocation in the Government of Tajikistan

The assessment of natural hazard-related risks, the review the risk-analysis findings and the use the data generated should be organized to involve all concerned relevant Government authorities. The elements of the Government of Tajikistan involved as partners in risk assessment activities are set out below.

- Authorities, organizations and institutions tasked with research and analysis of natural conditions in Tajikistan, including those responsible for prediction of natural hazards and assessment of effects of natural disasters, and including the:
  1. Main Directorate of Geology, responsible for analysis and study of geological hazards (specifically, dangerous exogenic geological processes).
  2. State Hydro-meteorological Agency, responsible for analysis of hydro-meteorological hazards (dangerous meteorological phenomena and natural hazards caused by them, including avalanches, etc).
  3. Institute of Geology, Seismic construction and seismology, Academy of Sciences of the Republic of Tajikistan, responsible for analysis and studies of geological hazards (specifically, seismic hazard).
- Authorities responsible for the regulation of the socio-economic development, industrial and agricultural production, uniformity of technical specifications and regulations. This group provides data on social, industrial and agricultural facilities, populated areas, territories that can potentially become risk receptors, and 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 the:

1. Ministry of Health.
2. Ministry of Agriculture and Nature Protection.
3. Ministry of Transport and Communications.
4. Ministry of Energy and Industry.
5. State Committee for Land Management, Geodesy and Cartography
6. Committee for Emergency Situations and Civil Defense.
7. Agency for Construction and Architecture.
8. Statistical Agency under the President of the Republic of Tajikistan.

- Authorities responsible for development and enforcement of government policy and regulations regarding short-term, mid-term and long-term strategies, programs and forecasts of socio-economic development for the country as a whole and internal regions, including disaster risk reduction programs. This group includes the:
    1. Ministry of Finance.
    2. Ministry of Economic Development and Trade.

6.4 Requirements for Data Documentation and Storage

Data for the risk assessment should be compiled in an electronic format such as Excel™ (*.xls) or Access™ database files (*.mbd). Data bases of dangerous natural processes and location of persons or facilities at risk must include spatial reference at a level of accuracy equal to 1:100,000. During field work, paper records can be used, but should be transferred to electronic (Excel™ (*.xls) or Access™ database files (*.mbd)) format as soon as possible.

Hard copy cartographic (map) information should be scanned at a resolution of not less than 300 dots per inch and stored in a *.tif format for subsequent geo-referencing.

Cartographic data risk assessments is expected to be provided in an electronic format compatible with the ArcGIS™ geo-database or as shape-files with a defined description of the projection (for shape-files in *.prj format) used for the data. In some cases, cartographic information can be presented as geo-referenced raster images with the projection indicated. During field work, cartographic information can be collected on paper but should be transferred, through scanning or annotation of existing geographic data bases, as soon as practicable.

7 IDENTIFICATION OF NATURAL HAZARDS

7.1 Natural Hazards of Tajikistan

Listed below are the natural hazards observed in Tajikistan which should be analyzed for the risk assessment:

- Seismic activity
- Geological: landslides, landfalls, rockslides, etc.
- Mudflows
- Avalanches
- Flooding, e.g., as a result of snow melting, heavy precipitation, lake outbreaks.
- High ground water
- Erosion

7.2 Assessment of Hazardous Natural Processes in Tajikistan

{The background information in this section is available from the Committee of Emergency Situations, Government of Tajikistan.}

7.3 Analysis of Exposure to Hazards in Tajikistan

{The background information in this section is available from the Committee of Emergency Situations, Government of Tajikistan.}

8 ASSESSMENT OF VULNERABILITY TO NATURAL HAZARDS

The assessment of vulnerability to natural hazards is based on the expected intensity of the hazard with respect to the object (e.g., location, facility, goods, person or persons, etc.) during a specific period of time. Vulnerability to natural hazards is based on

- An assessment of actual (ex post facto) economic damage of similar entities (location facilities, goods, person or persons, etc.) having experienced hazard events of similar intensity and, or
- Calculations of virtual deformations of the assessed location facilities, goods, person or persons, etc., where maximum permissible ratings (generally set in construction codes),

using the general formula:

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

where

- $V_e(H)$ is the facility's economic vulnerability to hazard event H, defined by the frequency and intensity (in unit fractions) of the hazard.
- $D_d(H)$ is the possible damage from the hazard event impact and expenses required to compensate for these impacts, in monetary terms (e.g., Somoni, $US).
- D_c is the facility cost before the impact in monetary terms (e.g., Somoni, $US).
- i is the physical element impacted by the hazard event.
- N_i are the 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} is the portion of the damage cost from destruction of a part of the facility against the total losses from the accident.
- n - the number of individual elements within the facility.

All cost values calculated for a specific period of time, that is the specific frequency of the hazard event under consideration.

The physical wear (degradation from the initial state at time of construction) should be determined for facilities covered by the assessment using the following formula:

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

where

- $V_c(H)$ represents economic vulnerability of the operated facility to the H hazard;.
- V_e - initial economic 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:

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

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

where

- W_c represents physical wear of an element or system within the facility based on its examination in accordance with regulatory and procedural guidelines.
- P_i is dimensions (area or length) of the damaged portion of the element or system.
- P_c is the original dimensions of the element or system.
- m is the number of damaged portions.
- K_{ci} is the portion of the damage cost from destruction of a part of the facility against the total losses from the accident.
- n is the number of individual elements or systems within the facility.

If there are no data indicating wear or depreciation of a facility, the level of wear may be determined based on data for the same facilities in other locations.

The vulnerability of buildings and structures to individual hazard events 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).
- $S_d(H)$ is the area within the facility affected by the hazard H (m^2);.
- S_f is the total area of the facility (m^2)
- W_s is the physical wear of the facility.

Vulnerability of facilities located directly in the down or upslope impact zones of landslide, landslip or rockslides should have a value of one. In all other cases vulnerability to landslides should be determined based on the formula (1).

The vulnerability of facilities to seismic impact is determined based 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 equal to one. The overall vulnerability of such facilities should be determined based on their exposure to a hazard based on formula (1).

Vulnerability of territories to natural hazard H of a specific frequency and intensity is assessed in physical and economic terms using the following formulas:

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

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

where

- $V_{tf}(H)$ and $V_{te}(H)$ represent respectively physical and economic vulnerability of the territory to the hazard H (in unit fractions).
- $S_d(H)$ is affected area within the territory in case of sporadic manifestation of the hazard H (m^2, hectares, km^2).
- S is the area under assessment (m^2, hectares, km^2).
- D_{td} is the value of the affected portion of the territory (e.g., Somoni, $US).
- D_{te} is the total value of the territory under assessment (e.g., Somoni, $US).
- K_t is the portion of cost of damage of the affected area against total value of the a specified area being assessed.

The value of land plots is based on their cadastral value. If no cadastral value is available the value should be based on the value of agricultural production from the area being assessed for the five years preceding the assessment.

Social vulnerability of population to the natural hazard H is determined using the following general formula:

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

where

- $V_s(H)$ is an indicator of social vulnerability - the proportion of persons affected as the result of a natural hazard impacting a facility or location.
- $P_d(H)$ is the number of persons who would lose their lives as a result of actualization of the hazard H (number of persons).
- P_t is the overall number of people staying in the affected area (number of persons).

- $V_t(H)$ is the physical vulnerability of the territory or economic vulnerability of the facility to the hazard H based on formulas (6), (2) or (1) (unit fractions).
- $V_{st}(H)$ is the social vulnerability of a population in time which is equal to the possibility of a person happening to be in a facility or undeveloped areas at the time when they are affected by the hazard H (unit fractions).
- $V_{ss}(H)$ is the 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 people of different ages and professional background are in an at risk facility using the following formula:

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

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).

When assessing the vulnerability of populations to quick on-set natural hazards the use of data on physical, economic and social losses caused by different natural hazards on facilities structurally or functionally similar to the ones under assessment is recommended. Should such data be unavailable, social vulnerability of population within facilities may be established based on any decision taken at a time of implementing prevention and risk reduction measures. (Literal translation from the Russian).

9 QUANTITATIVE RISK ASSESSMENT

9.1 Calculation of Physical and Economic Risk

The assessment of geological risks should be done in a consistent manner for all locations, facilities and systems assessed taking into account the nature of the hazards and period for which relevant information is available. However, information more than 50 years old should not be used due to the change in the nature of facilities and locations during this period.

All results should be presented as risk per year.

The economic risk of losses from seismic events, landslides, rockslides, mudflows, soil subsidence caused by water-logging, liquefaction and scouring of soil, and from other quick on-set natural hazards can be assessed as complete and specific (reduced to a unit of area) risk values using the following formulas:

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

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

where

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

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

A complete assessment of risk of economic loss from erosion processes, ravine erosion and other natural hazards characterized by a relatively continuous development in time and space, is determined based on the speed with which those hazards may affect facilities being assessed using the formula:

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

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).
- $P(W_h)$ is the likelihood of actualization of the speed.
- $V_e(H)$ is the economic vulnerability of the facility.
- d_e is the facility value reduced to a unit of its area (specific cost of fixed assets, Somoni/m^2, Somoni/ha, Somoni/km^2).

A complete assessment of risk from slow sagging and changes in land surface due to soil subsidence is determined using the formula

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

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 (Somoni).
- T_c - service life of the facility (years).

Specific values for the risk of economic loss from the 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 hazard process on-set speeds and average deformation be used whereas the likelihood of the hazards' actualization during the service life of the facility should be equal to one.

The assessment of the level of risk due to economic loss for locations and facilities of historical or architectural value should use formulas (10) – (14). The cost of these facilities before an impact by one or several hazards should be substituted by their reconstruction cost.

The assessment of economic loss risk for locations and facilities requires an assessment of natural hazards on adjacent territories which may become active at the same time as the direct hazard being assessed.

The risk from multiple manifestations of an individual natural hazard of a specific frequency and intensity or for several hazards affected the same location of facility is determined as the sum of differentiated risks from those hazards calculated by the formulas (10) – (14). This process can be performed for single hazard types, or for several different hazard types together, affecting the same location or facility.

9.2 Social Risk Assessment

The risk of social losses of populations due to quick on-set natural hazards such as earthquakes, landslides, rockslides, mudflows, avalanches and floods is based on the location of the population at the time the hazard impact occurs.

The social risk from quick on-set natural hazards is determined by assessing 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 of death from the hazard H equal to the likelihood of such an event happening to one person in a group staying within the assessed facility or location (person per person years).
- P*(H) is the recurrence period of hazard H (events per year).
- $V_s(H)$ is the social vulnerability of population to the hazard H determined using the formulas (8) and (9), or based on Annex 5
- $R_s(H)$ is the social risk of dying from the hazard H equal to the number of fatalities due to the hazard H within a year (persons per year).
- D_p is the total number of population within the assessed location or facility (persons).

  The combined social and individual risk of death from several natural hazards affecting a location or facility is determined by adding the fatalities calculated in formulas (15) and (16).

Assessment of social and individual risk of life loss is mandatory when doing a feasibility study for activities to prevent disasters linked to natural hazards.

10 IMPLEMENTING THE DISASTER RISK ASSESSMENT METHODOLOGY USING GEOGRAPHIC INFORMATION SYSTEMS

10.1 Source Data Requirements

{This section has been removed from the English version. It contains a standard description of the structure of a Geographic Information System (GIS) and is not specific to the risk assessment process developed for Tajikistan.}

10.2 Use of Remotely Sensed Data

{This section has been removed from the English version. It contains a standard description of how remotely senses data is incorporated into a GIS and is not specific to the risk assessment process developed for Tajikistan.}

10.3 Processing of digital mapping data in risk analysis

Processing electronic cartographic data and conducting spatial analysis should be carried according to the requirements of Section 6. An overview of the spatial analysis process to assess natural hazards and risks can be found in Figure 5. A flow chart on preparing electronic cartographic materials on the spatial distribution of natural hazards can be found in Figure 6. A flow chart on preparing source electronic cartographic materials on risk-impacted locations and facilities is provided in Figure 7.

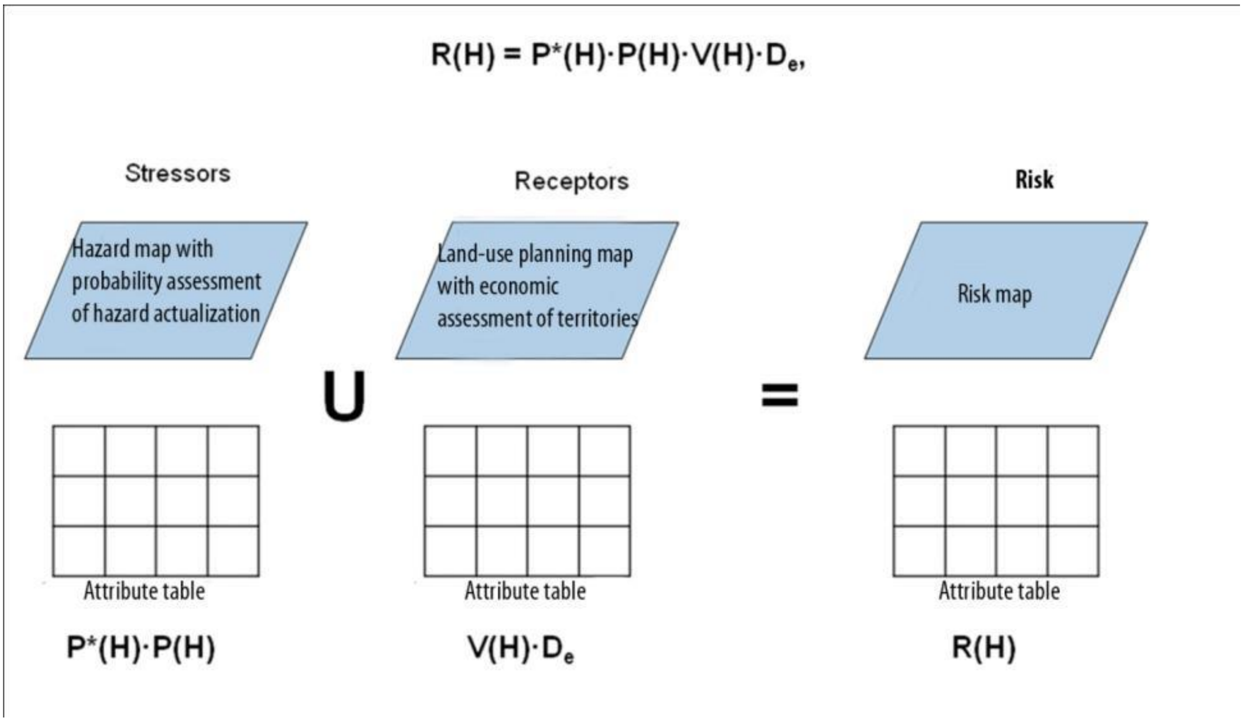

Figure 5. Overview of the spatial analysis process to assess natural hazards and risks.

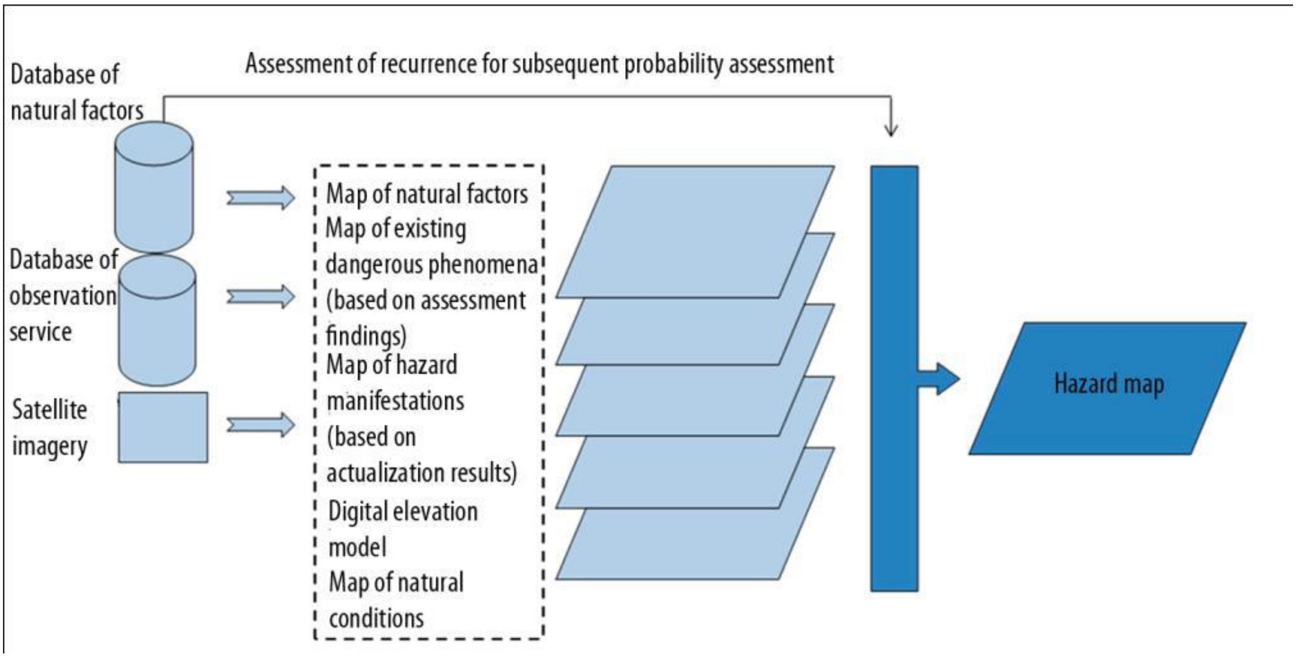

Figure 6. Flow chart for preparing source electronic cartographic materials on the spatial distribution of natural hazards.

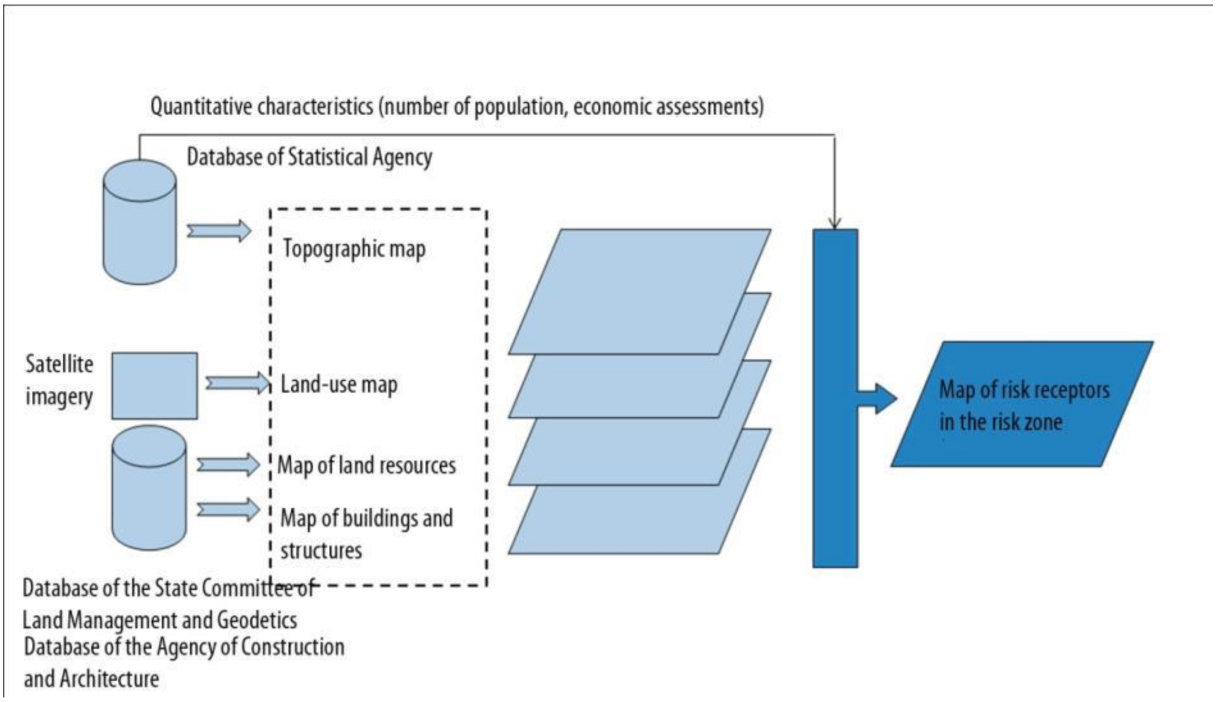

Figure 7. flow chart on preparing source electronic cartographic materials on risk-impacted locations and facilities.

10.4 Deliverables: Maps and Reports

The results of the risk assessment should be presented in the form of maps covering individual risks, combined risks, loss of life and economic damage in a level of detail which meets user requirements for risk reduction.

All risk assessment results and maps should be substantiated by detail reports indicated the procedures and data used in the assessment process and additional details needed to understand and use the risk assessment results.

11 CONCLUSION

Assessing disaster risk and ranking risks to facilities and populations aids in planning and implementing risk reduction work. Risk reduction can bring risk down to acceptable levels. The concept of economic analysis in competitive business environments provides two key approaches which can be used to assess risk reduction options.

The first approach, cost-benefit analysis, is based on the concept that social and economic risk can be reduced when the benefits from risk reduction are higher than the costs of the actions needed to reduce the level of risk.

The second approach, cost effectiveness evaluation, holds that the reduction of social and economic risks must be achieved at the lowest possible cost. The cost effectiveness evaluation can 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). The second approach is d most widely used although it does not answer the question: to what level should risk be reduced. As well, the cost effectiveness approach avoids discussion as to what risk level can be considered acceptable. As a result, this second approach is suited for situations when a decision maker has only limited financial resources and wishes to achieve the maximum risk reduction with limited resources.

Decisions on the adoption of a risk-reduction action plan are taken based on an economic analysis of risk minimization alternatives. This action plan provides the justification for the priority rating of risk reduction activities based on criteria of cost efficiency per risk reduction unit.

As a result, the economic justification of a risk reduction strategy is based on the cost efficiency analysis of risk reduction activities. This analysis is needed to justify priorities when implementing risk reduction activities and for the rational allocation of limited financial resources available for such activities. This approach provides for the best risk reduction scenario and risk reduction action plan.

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

- Identification and prioritization of base-line risk levels.
- Drawing up of a list of future projects and possible decisions aimed at risk reduction.
- Identification of risk reductions that can be obtained from implementation of every such activity.
- Evaluation of implementation costs for each of the proposed risk reduction activities.
- Calculation of the marginal cost value of risk reduction for each risk reduction

activities.

- Priority ranking of activities based on the criteria of costs per unit of risk reduction.

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ANNEX 1 - COMPOSITION OF THE WORKING GROUP TASKED WITH DEVELOPMENT OF DISASTER RISK ASSESSMENT METHODOLOGY FOR 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

(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 Disasters

Classification code	Type of Disaster*	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 Disaster by Hazard Type

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	

Disaster Subtypes

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	2	3	4	5	6
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-:-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 – STANDARD CONTENTS REQUIREMENTS FOR DIGITAL CARTOGRAPHIC MODEL

Includes 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.

ANNEX 5 – CORRELATION BETWEEN VULNERABILITY OF WEAK BUILDINGS AND STRUCTURES AND POPULATION EXPOSURE BY HAZARD TYPES

(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.