Republic of Moldova
Ministry of Economy
Department of Civil Protection and Emergency Situations

METHODOLOGICAL RECOMMENDATIONS FOR PLANNING OF MEASURES FOR COMBATING NATURAL DISASTERS, ACCIDENTS AND CATASTROPHES

Chisinau, 1996

Methodological recommendations

on planning of measures for combating of natural disasters, accidents and catastrophes have been elaborated by Ph.D. Ion Patratii, chief of the emergency situations division within the Ministry of Economy, and colonel Tudor Grama, deputy chief of the Department of Civil Protection and Emergency Situations.

The present recommendations have been elaborated according to the requirements of the United Nations Development Programme in the Republic of Moldova, project MOL/94/005/A/14/99. Messrs. L. Culiuc, P. Pasat, G. Cutasevici and A. Glinca took part in preparation and editing of the work.

TABLE OF CONTENTS

Introduction

The current tendencies of humanity development are characterised by the growing density of population, economic facilities and transport, many of which use in their technological processes or transport a huge volume of toxic, inflammable and radioactive substances, other raw materials, which in case of a disaster can cause substantial material and human losses and environment pollution. The consequences of natural disasters become more grave and frightening in present conditions, and some accidents and catastrophes can cause transnational disasters. The problem of resistance to natural disasters, accidents and catastrophes gets a global importance and needs to strengthen the efforts not only of certain countries but of the international community.

All these confirm that a hazard for the life of each inhabitant of the planet has grown up. It is time to elaborate and approve commensurable methods for assessment of degree of such hazards, methods for carrying out of purposeful actions to reduce these hazards both at the local and national or interstate levels.

Hereinafter, based on some examples of natural disasters, accidents and catastrophes possible in the Republic of Moldova, there are shown some destabilising and affecting factors of these phenomena, methods for vulnerability assessment of economic facilities, population and environment, there are proposed simplified methods for assessment of consequences of primary sources and avalanches of secondary sources' activation, criteria for hazard degree assessment of a separate source and their totality; there is presented a classification of size of possible emergency cases and of measures for combating hazard sources, methods for efficiency assessment and selection of rational measures at different levels of administration, which need to be use in practice for a complex planning of measures aimed at combating natural disasters, accidents and catastrophes.

The authors have designed the present methodological recommendations for the specialists, who are working on elaboration, designing and planning of measures for combating natural disasters, accidents and catastrophes. They can be useful for students of high establishments and postgraduate students as a manual on civil protection.

1. Natural disasters, accidents and catastrophes possible in the Republic of Moldova, their interaction and consequences

1.1. Natural disasters

Earthquakes (with an epicentre in Romania, Vrancea region, the Carpathian Mountains). The maximum intensity of the earthquakes is of 6-8 degree according to 12 degree scale accepted at the international level, the duration varies from 20 to 60 seconds. The earthquakes can cause destruction of seismically non-resistant buildings and constructions and also accidents on industrial facilities. Material losses provoked by earthquakes can reach the level of 5 percent of the potential gross domestic product (GDP).

Catastrophic floods. They can occur as a result of torrential rains, intensely snow-melting, dam failure at the reservoirs on the Nistru, the Prut and the Bic rivers, and as a result of dam failures at the artificial ponds. The highness of breaking waves, their speed and flooded area can be calculated. The results of these calculations for different sources of possible flooding have to be presented by the Department of Civil Protection and Emergency Situations. Catastrophic floods, depending on the parameters of breaking waves, can cause losses of harvest, material losses, destruction of buildings and constructions (roads, bridges, etc.).

Depending on the size, catastrophic floods can provoke material losses from 2 to 30 percent of the potential GDP.

Hail storms. They appear with the heavy rains during hot weather, and take place nearly every year and can cover significant areas the diameter of hails can reach 6 cm and width of the soil coverage can be around 10 cm. Complete or partial losses of agricultural harvest, wounding of livestock, destruction of roofs and windows of buildings can occur in the zones affected by hail storms. Material losses provoked by heavy rains with hails can reach up to 2 percent of the potential GDP.

Drought. It occurs because the air temperature keeps high for a long period of time in combination with a lack of sufficient quantity of precipitation for plant growth. In the republic they occur periodically of 3-5 years and cover the southern and the central part of the republic. Drought causes substantial losses of harvest (from 10 to 50 percent). Shallowing of rivers and decrease of underground water level can provoke difficulties in drinking water supply to settlements.

Land slides. They can occur in years with abundant atmospheric precipitation. Around sixteen thousand land slide areas have been registered in the republic, most of which is the result of irrational land use. In case of land slides, irretrievable agricultural land and harvest losses, damaging of buildings and constructions, population and livestock losses are possible.

Sharp change of temperature from positive one to - 25 C in winter time accompanied by a lack of snow cover. It occurs once in 10 years and can provoke a loss of up to 40 percent of winter crops and loss of from 2 to 10 percent of the harvest of orchards and vineyards.

Spring and autumn frosts - sharp change (during plant vegetation period) of temperature of soil surface or of air near soil from positive temperature to negative of - 3 to - 10 C. They occur nearly every year and can cover a considerable part and, sometimes, the whole territory of the republic. This can cause deterioration or loss of plants, future harvest loss (in case of late frosts) or of collected harvest (in case of first autumn frosts). The losses of harvest in general can reach 10 % in the republic.

Snow-drifts. They cover the whole or a part of the republic's territory, roads and communications (as a result of intense snowfall and snowstorms) with a snow layer of up to 85 cm. They provoke a stop of transport, and as a result of this, stoppage of food supply to the population and of raw materials to the enterprises.

Icing of roads, communication and electrical transmission wires, multi-annual plantations. It can occur during winter time at negative temperature and fall of liquid precipitation. Icing of roads makes difficult transportation, creates emergency situation. Communication and electrical transmission wires can be iced over with a layer of ice up to 1,9 kg of weight on 1 linear meter of wire. They can cause cut of wires, interruption of energy supply and telecommunications.

Hurricanes (tornadoes) with a speed of more than 27 m/sec. They can cause damage of trees, houses' roofs, etc.

Epidemics (mass disease of population). It appears as a result of high activity in nature and among population of pathogens of many contagious diseases in certain climacteric and other conditions (such as natural disasters, water and air pollution with viruses and bacteria, chemicals and radioactive substances, sharp reduction of living standard and of anti-epidemic measures in the condition of economic falling-off). They can appear on a part or on the whole territory of the republic. The most possible contagious diseases are typhus-paratyphoid, sharp intestinal diseases, viral hepatitis, diphtheria, cholera, plague, anthrax, spotted fever, etc.

Epizootic (mass disease of livestock). In some regions of the republic pig plague and Newcastle disease of poultry are registered. They appear as a result of highly concentration of livestock and poultry in separate farms together with low discipline of disease prophylactics. Annual losses of livestock and poultry from different diseases reach from 0,5 to 2 per cent of the total livestock in the republic.

Epiphytoxics (mass disease of plants). They can appear nearly every year, but due to the efforts of the plant protection services comprising certain measures of combating diseases and pests, the losses of harvest from these factors are in the range of 5 -15 %.

1.2. Accidents and catastrophes

Human victims, material losses and environment pollution of different sizes are likely to occur because of accidents and catastrophes on the industrial enterprises and transport both of the republic and of the neighbouring countries (Ukraine, Romania, Bulgaria). In case of accidents and catastrophes the following impact on population, economic facilities and environment of the republic can be expected:

- catastrophic floods as a result of dam disable of hydrological constructions at the Nitru and the Prut rivers;
- contamination of a certain territory with chemically hazardous substances (chlorine, ammonium, sulphuric and cloric acids from 2 to 250 tonnes) as a result of an accident on a single or several enterprises, as well as a result of an accident or catastrophe on the railroad or auto-transport while transporting chemically hazardous loads. Human and material losses in the affected zone by poisonous substances can be significant;
- affecting influence of the breaking wave in a hazardous zone near highly explosive enterprises in case of an accident. The breaking wave affects population and livestock, causes different type of buildings and constructions' damages. Many such enterprises are functioning on the territory of the republic (bread-baking plants, boiler-plants, sugar-refineries, power stations, gas stations, gas pipelines, etc.)
- impact and spreading of fire in case of fires on a single or several functioning fire hazardous enterprises (oil stations, woodworking enterprises, bread receiving stations, carpet and cotton factories, etc.). It can cause destruction of material assets on neighbouring enterprises, human losses;
- bacteriologic and chemical pollution of the Nistru river caused by the accidents on sewage plants in the cities of Tiraspol, Ribnita and Bender, which can provoke contagious and other diseases of population and livestock in settlements, which use the river water for drinking purposes;
- high pollution by aggressive chemicals of the Nistru river on the territory of the republic in case of failure of settling tanks in the Novo-Razdolisk, Stebnikovsk and Kalushsk chemical plants in Ukraine. The pollution can provoke the death of live organisms in rivers and poison people and animals. In case of a such pollution during several months the water of the Nistru river could not be used for drinking;
- chemical pollution of the Prut river in case of emergency chemicals discharge on the enterprises of the Iashi region to the Hijia river in Romania. The consequences for the Prut river and inhabitants of its river basin are similar to those in case of the Nistru river pollution;
- hazardous radiological contamination for the health of people and animals of the whole or a part of the republic's territory in case of accidents on the nuclear power plants in

Hmelnitsk, Iujno-Ukrainskaya, Rovensk, Zaporojsk and Chernobyl in Ukraine and Chernavoda and Oltenitsa in Romania, Kozlodui in Bulgaria. Approximately the same radioactive pollution of the whole territory or of a part of the republic can occur in case of accidents on the nuclear power plants mentioned above and in certain circumstances (wind direction during the accident, size of the accident etc.), which was registered in Byelorussia, which suffered more from the accident at the Chernobyl nuclear power plant.

1.3. Destabilising and striking (affecting) factors

Each of the undesirable phenomena mentioned above is a source of certain destabilising and affecting factors. The destabilising factors lead to a temporary break of economic links and of normal conditions for population activities. Zones of snow-drifts and icing up of roads, flooding zones of transport communications, zones of thick fogs and others can be attributed to the destabilising factors.

Affecting factors lead to mechanical, chemical, thermal, radiological, bacteriological destruction of the national economy's elements (enterprises, buildings, installations, population, animals) as well as to pollution of environment.

Mechanical destruction is caused by soil vibration during earthquakes, explosions on fire hazardous and dangerous explosive plants during transport collision, breaking wave during catastrophic floods, energy of hailstones during hailstorms, weight of ice during icing over electricity transmission wires, pressure of air masses during hurricanes and squally winds, etc.

Thermal destruction is possible in case of thermal emanation during fires and strong droughts, of sharp decrease of temperatures in wintertime, of the first autumn frosts and the late frosts.

Chemical destruction of population and environment is possible in case of an impact of strongly poisonous substances, fuel-oil, other aggressive reagents during accidents on chemical hazardous plants, sewage installations, different store-houses and transport.

Radioactive destruction can happen in case of an impact of radioactive substances spreading as a result of accidents on nuclear power stations and other enterprises using radioactive substances, accidents during transportation of these materials.

Mass bacteriological destruction by pathogenic bacteria and viruses is possible in case of disregarding of sanitary conditions as a result of disabling of life-support systems influenced by mechanical, thermal, chemical and radioactive destructive factors during pollution of water-supply systems and water sources by emergency discharges from sewage installations, unfavourable climatic conditions, which can cause activation of the existing pathogenic organisms, etc.

In order to plan the measures designed for prevention and mitigation of losses caused by destabilising and affecting factors of the possible natural disasters, accidents and catastrophes there is a strong need to have authentic knowledge about the sources of these factors, vulnerability degree of the elements of the national economy (enterprises, buildings, constructions, population, animals and agricultural plants), and of environment in case of an impact of separate factor or their totality of different force, reduction of vulnerability and possible elements and environment's damage mentioned above depending on the envisaged measures for reduction of vulnerability and protection, expenditures for implementation of these measures.

1.4. Ramified chain of undesirable phenomena, size and zones of their impact

The action of destabilising and destructive factors of certain natural disasters (phenomena of natural origin) can cause a chain of accidents and catastrophes (phenomena of technological origin), which, in case the preventive measures are not undertaken in time, increase the possible human and material losses. Accidents and catastrophes of one type may provoke a chain of other accidents in their turn (e.g. explosion on an enterprise can cause fire, discharge of strongly poisonous substances in environment, radioactive contamination, etc.).

As an example a ramified chain of dependant undesirable phenomena possible after a strong earthquake can be presented in the following order.

Earthquake, which can cause the following:

1. Destruction of dams on hydro-constructions as a result of soil vibration caused by an earthquake.

1.1. Catastrophic floods as a result of dam failure on hydro-constructions.

1.1.1. Destruction of roads and bridges as a result of breaking wave's influence.

1.1.1.1. Accidents on transport as a result of road destruction.

1.1.1.1.1. Explosions, damage of tanks with fuel and poisonous substances as a result of an accident on transport.

1.1.1.1.1.1. Discharge and washing away of fuel and poisonous substances, pollution of environment causing human losses and animal losses.

1.1.2. Destruction of buildings, constructions, technological equipment influenced by breaking wave.

1.1.2.1. Discharge of combustibles and poisonous substances, of wastes of sewage plants as a result of destruction of buildings and constructions, pollution of environment causing human and animal losses.

1.1.2.1.1. Appearance of epidemics.

1.1.2.1.1.2. Appearance of epizootic.

1.1.3. Annihilation and damage of agricultural plants and animals, washing away of soils by the breaking wave.

1.1.4. Destruction and damage of electricity transmission wires by the breaking wave.

1.1.4.1. Fires on electric power stations as a result of destruction of electrical transmission wires.

1.1.4.2. Accidents on industrial plants with continuous technological cycle as a result of sudden electricity turn off.

2. Destruction and damage of buildings, constructions and technological equipment as a result of soil vibration during an earthquake.

2.1. Fires as a result of buildings and constructions' destruction.

2.2. Explosions as a result of buildings and constructions' destruction.

2.3. Discharge of fuel oil, poisonous and radioactive substances, wastes of sewage installations as a result of destruction of buildings, constructions, technological equipment, pollution of environment causing death of people and animals.

2.3.1. Appearance of epidemics.

2.3.2. Appearance of epizootic.

3. Landslides as a result of soil vibration during an earthquake.

3.1. Taking agricultural lands out of circulation as a result of landslides.

3.2. Damage of buildings, constructions and technological equipment as a result of landslide.

3.2.1. Fires.

3.2.2. Explosions.

3.2.3. Discharge of fuel oil, poisonous and radioactive substances, wastes of sewage installations as a result of destruction of buildings, constructions, technological equipment, pollution of environment causing death of people and animals.

3.2.3.1. Appearance of epidemics.

3.2.3.2. Appearance of epizootic.

Probability of appearance of one or another phenomenon within a ramified chain of phenomena mentioned above depends on an earthquake intensity, i.e. it depends on the size of the primary phenomenon, which can occur with a certain probability. The primary phenomenon actually determines the spacial size of the disaster, indices of possible victims and material losses. Simultaneously, the possible disaster size, indices of possible victims and material losses depend on the earthquake intensity and on vulnerability degree of dams on hydrological and other constructions, buildings, technological equipment, their location on the territory in relation to relief, which can increase, decrease or exclude completely the appearance of a chain of secondary unfavourable phenomena; on measures undertaken to prevent landslides and non-location of facilities in landslide and flooding zones; on operative measures undertaken to suppress the undesirable phenomena immediately after the appearance of the primary phenomenon (localisation of consequences), etc.

By analogy, there are determined the ramified chains of undesirable events caused by the influence of destabilising and affecting factors of other primary natural disasters (floods, provoked by heavy rainfalls or snow-melting; hailstorms, drought, landslides; ice formation; hurricanes; epidemics, etc.) or man-made disasters (accidents and catastrophes of different types).

Each natural or man-made disaster mentioned above, as an independent phenomenon, as well as ramified chain of undesirable phenomena, as a consequence of the previous phenomena, has a certain probability of appearance and represents a potential danger for population, facilities and environment.

Zones of potential danger can be the following:

- risk zones in case of earthquake with intensity of 6 and more degrees according to 12 degree scale;
- risk zones in case of floods of natural and man-made character;
- risk zones in case of hailstorms;
- zones of possible drought;
- landslide zones;
- zones of first autumn and late frosts;
- zones of possible sharp (catastrophic) changes of temperatures from positive to deep negative in winter time in combination with a lack of snow-cover;
- zones of snow-drifts on transport communications;
- zones of possible icing over road, communications and electrical transmission wires;
- zones of possible hurricanes and squally winds;
- zones of epidemics;
- zones of epizootic;
- zones of epiphytoxics;
- zones of possible environment pollution by poisonous substances during accidents on chemical enterprises of the republic and from abroad;
- zones of possible dangerous influence of breaking wave on inflammable hazardous plants;
- zones of possible fire influence during fires on inflammable hazardous enterprises;

- zones of possible bacteriological and chemical contamination during accidents on sewage installations of plants and cities;
- zones of radiological contamination during accident on nuclear power stations of the neighbouring countries and other hazardous radiological facilities.

For each primary source of potential hazard, proceeding from the conditions of maximum possible actions of destabilising and affecting factors of the same source and taking into consideration the possible appearance and action of undesirable phenomena, the hazard zones are indicated on the map of the republic. The zones, that are indicated on the hazard maps from different potential sources, represent the zones of high risk and require a special attention and implementation of preventive measures to reduce vulnerability of population and economic facilities.

1.5. Size of emergency situations

Emergency situations of different size can be created in one or several districts of a potential hazard depending on the intensity of destabilising and affecting factors of primary and of possible chain of undesirable phenomena as well as depending on the early preventive measures to reduce vulnerability of population and economic facilities.

Emergency situation are situation on a certain territory created as a result of accidents, catastrophes, disasters and other calamities, which can cause or caused human losses, damage of human health and environment, significant material losses, worsening or complete breach of living conditions of population.

Emergency situations can be of local, district, republican and international size depending on the impact of destabilising and affecting factors, human and material losses caused by them.

An emergency situation is considered of district (municipal) size if in one town (city, settlement) one or all maximum indices mentioned above exceed indices of local size, but in general in district (municipality) affect no more than 4% of territory of district (municipality), caused human losses or put in danger life and health of no more than 2% of population and caused (or can cause) material losses of no more than 3% of the district (municipality) property costs.

An emergency situation is considered of republican size if in at least one of districts (municipality) one or more indices of this situation exceed maximum indices of district (municipality) size , but in general in the republic damage no more than 8 percent of its territory, cause human losses and endanger life and health of no more than 4% of population and can cause (or caused) material loses no more than 6% of the republican property cost.

There are insufficient the efforts of the republic and a foreign help is required if the maximum indices a republican emergency situation to emergency situation exceed maximum republican size for localisation and relief. .

Specialised means and forces of higher level can be used in case of aggravated circumstances as well as in case of a lack or putting out of function of required means and forces for localisation and emergency relief of lower size.

2. Measures for combating of natural disasters, accidents and catastrophes

Measures for combating of natural disasters, accidents and catastrophes are divided into the following groups:

- follow up of hazard sources. Follow up, registration, study and control of possible sources of destabilising and affecting factors, evaluation of possible size and influence of these factors;
- influence on hazard sources. Influence on possible sources of destabilising and affecting factors (their management if possible) to exclude or to mitigate their hazardous impact (activity);
- follow up of the state of affairs and vulnerability assessment of economic facilities and environment. Follow up, registration, study, control of economic facilities and environment influenced by destabilising and affecting factors, assessment of their vulnerability depending on the possible influence of separate or a totality of destabilising and affecting factors;
- reducing of vulnerability of economic facilities and environment. Increasing of resistance of economic facilities and environment to the influence of destabilising and affecting factors of natural disasters, accidents and catastrophes;
- timely protection. It comprises implementation of such measures that would exclude or mitigate the influence of destabilising and affecting factors on economic facilities and environment in case of natural disasters, accidents and catastrophes;
- warning about danger. Warning of population, decision-makers and public authorities about danger in case of activation of sources of destabilising and affecting factors;
- operative protection and rescue. Limitation of spreading of destabilising and affecting factors, evacuation of population and material values out of the hazard zone, rescue of victims, rendering of medical assistance and material aid;
- rehabilitation. Planning and implementation of rehabilitation (restoration) of economic facilities and environment subjected to the influence of destabilising and affecting factors;
- training of population, decision-makers and public authorities. Getting of theoretical knowledge and practical skills by population, decision-makers and public authorities on planning and implementation of necessary measures and activities in emergency situations.

2.1. Observance of hazard source

Statistic data (data for previous years); measuring instruments for permanent and periodic control of parameters that characterise state of affairs and intensity of each destabilising and affecting factors source; source behaviour models (mathematical, analogous) are used to get knowledge about each destabilising and affecting factors' source. On the basis of knowledge obtained forecast for destabilising and affecting factors' behaviour is created, which depending on the degree of study of certain processes can be as concrete calculations of source behaviour in time, as probability or expert evaluations. For instance, lack of knowledge about the majority of processes taking place in the earth's crust and in atmosphere do not allow to forecast in time the parameters of the majority of natural disasters. That is why, statistical data contribute only to the estimation of intensity and periodicity of one or other phenomena, expertise of possible parameters of destabilising and affecting factors.

The most studied and easier to observe are the processes taking place in the atmosphere and due to this it is possible to warn public authorities, population about possible danger earlier than in case of an earthquake.

Now, the periodicity of drought and catastrophic floods can be forecast relatively precisely. Zone of droughts is the centre and the southern part of the republic. Zones of floods are the river basins, places of water during heavy rain falls. The maximum unfavourable conditions during droughts are the decrease of precipitation by 40-50 per cents from the standard and increasing of temperature by 1-3 degrees C in the period of plant vegetation. The maximum parameters for floods are calculated taking into account the relief and precipitation during 5-6 hours in quantity of 40-50 percents of the annual norm.

The nature of landslides, causes of their appearance, zones of their action, as well as the main preventive methods are well studied, but due to the imperfection of legislation regarding the responsibilities of land-users for the safety of land and high costs for the measures for preventing landslides, new zones appear and the old ones are still activating that cause losses of arable lands, destruction of buildings and constructions, other losses.

Technological processes on industrial enterprises and transport, which can cause accidents and catastrophes with hard consequences are relatively easy to study. This allow to elaborate concrete measures which will prevent accidents and catastrophes, but to exclude them completely it is practically impossible because of unreliability of the systems for technical management, block and protection systems as well as due to participation of people in the management of technological processes, who by infringing the safety rules (by an oversight or low professional qualification) contribute to the appearance of emergency situations. Thus depending on the status of technological protection systems, employees' qualification, labour discipline and results of analysis of the causes of the accidents and catastrophes, which took place earlier, the specialists issue expert evaluation of probability of appearance of theses events and calculate the size of action of the possible destabilising and affecting factors.

The most probable zone of appearance and spreading of pathogenic microbes and viruses are the places of possible breaking of sewage system, wastes and purification systems, places of extremely high concentration of population and animals, natural canter of pathogenic organisms. Activity of infection in a certain degree depends on climatic conditions and status of environment of live organisms in a certain place. On the basis of the scientific data, experience of the previous years and concrete conditions for hazardous zones specialists in health protection, protection of animals and plants elaborate and periodically

update the risk assessment for diseases and size of their action for each type of possible infection.

A special services equipped with required apparatus and equipment are established to observe over hazard sources and to forecast the possible size of their activity.

2.2. Influence on hazard sources

Insufficiency of knowledge and level of modern technical development do not allow to influence on the majority of destabilising and affecting factors in order to prevent and mitigate them.

Such natural disasters as hailstorms, landslides, epidemics, epizootic are studies and preventive measures can be undertaken.

Hazardous hail clouds can be timely identified and rendered harmless by an anti-hail services, thus preventing hailstorms. Influence on these clouds covers dispersion (dissipation) of substances, which cause rapid formation of harmless for the economy and environment small hailstones.

Landslides are prevented by respecting of land-use rules, planting of protective afforestation, building up anti-landslides constructions, etc.

Epidemics, epizootic can be prevented by respecting strictly the required prophylactic measures aiming at pathogenic organisms.

Prevention of accidents and catastrophes at the economic facilities, that cause catastrophic floods, discharge of poisonous, radioactive and different wastes, as well as fires and explosions, can be provided by respecting strictly the operation and safety rules; construction and assembling of machinery, equipment, buildings and constructions; systematic precautions and maintenance in order of production components and communications; creation and mounting of modern and safety automated and automatic management systems of technological processes and blocking of emergency situations, but excluding from the technological processes of hazardous substances, strengthening of constructions of hazardous buildings, installations, equipment, etc.

Practically for each type of hazard special services are established to observe them, study and elaborate measures with a view of preventing and mitigating their possible activation. Proved in practice and effective measures are approved as normative and compulsory ones for carrying out by economic agents, administrative bodies and population. Measures for preventing of hailstorms, epidemics, epizootic are carried out respectively by the anti-hail-hail service, anti-epidemiological and veterinary services, service for plant protection from the republican budget. Measures for preventing of landslides depending on the destination and size of possible consequences are carried out by different executors: for observing of land-use and protective afforestation rules by the land-users from their amount, for building up of anti-landslides engineering construction by the local authorities with the use of means of enterprises of local and republican budgets.

Measures for preventing of accidents and catastrophes on the enterprises are carried out by economic agents on their own account. Responsibility for caused losses to the economic elements and environment in case of activation of hazard sources for enterprises is carried out by the owners of these enterprises.

Control for implementation of measures for influencing on the hazard sources is responsibility of local and republican authorities and inspection. General control is fulfilled by the Department of Civil Protection and Emergency Situations.

2.3. Observance of the situation and evaluation of the vulnerability of economy and environment

Vulnerability assessment of elements of economy (enterprises, buildings, constructions, population, animals, plants, micro-organisms, etc.) And environment by that or other destabilising and affecting factors is carried out on the basis of vulnerability data of factors that occurred during prior natural disasters, accidents and catastrophes, as well as on the basis of experiments, analogies, scientific calculations, other methods.

Thus, for instance, vulnerability of buildings and construction depending on the earthquake intensity is calculated according to data regarding earthquakes that occurred in the past. Buildings and constructions are classified by types of their construction, and average data regarding their vulnerability are applied by analogy to all buildings and construction of this type. To determine the vulnerability and assess the effectiveness of engineering decisions, experiments are carried out with the help of installations, that imitate earthquake of different intensity with a view of increasing seismic resistance of buildings and constructions. Possible destruction of buildings and constructions determine the vulnerability of population, animals and material values that are in them during the earthquake.

Vulnerability of economic elements and environment depending on influence of catastrophic floods' factors (height and speed of the breaking wave, flood period) is judged on the basis of data regarding prior floods, on the basis of model experiments in special sites for studying of parameters and consequences of breaking wave influence, as well as on the basis of experimental data regarding resistance of constructions and live organisms in water environment, etc.

Vulnerability of economic elements depending on the size and intensity of hails is determined on the basis of expert assessment using statistical data of prior hailstorms. The most vulnerable are agricultural plants, roofs and windows of houses, greenhouses, drying-rooms and other facilities.

At the moment there are no methods for decreasing vulnerability of agricultural plants from hailstorms.

Data about vulnerability of plants during droughts are accumulated in the process of periodically repeated droughts, as well as in the process of laboratory experiments on growing up of plants in different temperature and humidity regimes.

Vulnerability of plants during sharp change of temperature in winter, during late and first autumn frosts is well studied using data of observations of many years. There are no methods for decreasing vulnerability of plants form these factors at the moment. The main method for decreasing of vulnerability of plants is selection of more frost-resistant plants.

Vulnerability of economic elements from hurricanes depends on physical and aerodynamic characteristics. It can be determined on the basis of natural observance or experiment on models in aerodynamic tubes.

Risks for diseases of live organisms influenced by pathogenic organisms and viruses in a significant degree depend on natural and acquired immunity inoculated as a result of prophilaxis, but risks of infection can increase while worsening of nutrition regimes of live organisms and living conditions (influence of toxic substances, radioactive radiation, worsening of sanitary and climatic conditions, etc.). Assessment of risks of contagious diseases depending on the factors and conditions mentioned above is done on the basis of statistical data regarding diseases and results of laboratory research.

Assessment if vulnerability of live organisms from the influence of strong poisonous substances and radioactive radiation is carried out on the basis of scientific and laboratory

research regarding influence on plants and animals. Certain data can be got from analysis of statistical data on poisoning and radiation diseases.

It should be mentioned that vulnerability of many economic elements (buildings, constructions, machinery, equipment) depends on degree of their physical depreciation and of degree of prior influence of destabilising and affecting factors. Thus services for periodical assessment of situation (passport) of these elements for satisfying safety rules.

2.4. Reduction of the vulnerability of economic elements and environment

Reduction of vulnerability means making economic elements and environment more resistant against influence of destabilising and affecting factors.

Thus for instance, reduction of vulnerability form influence of an earthquake means use in construction of such design and construction materials, that can provide seismic resistance of buildings and equipment maximum possible earthquake intensity for a certain locality. This decisions are legalised as typical construction norms, and maximum possible earthquake intensity for a certain locality is determined on the basis of scientific research and is issued a maps of seismic zonation and micro-zonation.

Reduction of vulnerability form influence of catastrophic floods means construction of resistant to water environment of buildings and constructions, streamlining them.

Vulnerability from hailstorms is reduced by using resistant row materials and glass.

The main methods for reducing plant vulnerability from drought is selection of drought-resistant species of plants, applying special technologies for growing up of agricultural plants.

Methods for reducing economic elements' vulnerability from hurricanes are increase of buildings and construction resistance and their most vulnerable parts, selection of plants with increased resistance and flexibility.

The main measures for reducing risks of contagious diseases are: increase of acquired immunity (mass vaccination, etc.), selection of animals and plants, less vulnerable to diseases, improvement of living conditions of live organisms.

Elaboration of methods for reducing vulnerability of live organisms from influence of poisonous substances are at the initial stage.

2.5. Timely protection

Measures on timely protection means (includes) timely construction of protective constructions and installations that exclude or mitigate the direct influence of destabilising and affecting factors on the economic elements and environment; location of facilities which are potentially hazard sources, population, water resources, resting places, etc. location of economic elements besides hazard zones.

Protective constructions and installations depending on such factors protect economic elements can be of different nature and construction (design). Thus, for direct influence of earthquake on buildings and constructions special ? foundation cushions are used, for protection against breaking waves during catastrophic floods - by-pass canals, protective barrages, reservoir cascades (for accumulation and regulation of water spreading), etc.

For protection of greenhouses and drying-rooms against protective nets and barriers are used and for plant protection against droughts - irrigation system of republican and local size.

For protection of plants against first and late frosts greenhouses can be used and also other methods of warming up of land air.

Protection of building and constructions against fire is carried out by establishment of automatic fire fighting systems, embankment ? of places of possible fire spreading etc.

For protection of population and animals against pathogenic microbes and viruses such measures as isolation of pathogenic carriers (quarantine measures), sanitary processing of places with high density of population and animals, other measures are applied.

Collective and individual protective means (shelters, anti-radiation shelters, gas masks) are used against influence of chemical and radioactive substances.

One of the most effective means of timely protection is location of potentially hazardous sites (chemical, using radioactive substances , fire and explosion hazardous sites, hydrotehnical and sewage systems, etc.) in such a way that in case of an accident on them, zone of action of destabilising and affecting factors does not comprise sites with high density of economic elements and thus harms less damage. For instance, new hydrotechnological installations (lakes, hydro power stations etc.) are located in such a way that in case of a dam failure population , industrial enterprises and other valuable sites not to be in the flooding zone.

In cases when the potentially hazardous sites are located already, in the zone of action of destabilising and affecting factors settlements other economic elements are not located. Economic elements are not placed as well in places of possible floods during heavy rains and snow-melting, in places of mass landslides, etc.

Responsibility for right location of potentially hazardous sites, as well as sites in zones of action of destabilising and affecting factors is carried out by the local authorities and Department of Architecture and Construction. Control for respecting of rules of right location of sites is carried out by the Department of Civil Protection and Emergency Situations.

2.6. Warning about danger

An important method of reducing possible damage from the influence of activated hazard source is timely warning of economic agents, local authorities and population about source and force of the coming danger, which allow to have time for organisation and carrying out of operative protection of economic elements and environment in accordance with the plans elaborated before. Systems of timely warning are built up and maintained in good shape for these purposes in zones of possible action of destabilising and affecting factors (in zones of catastrophic floods, possible discharge of strong poisonous substances, etc.).

2.7. Operative protection and rescue

In case of activation of hazard sources it is necessary to carry out immediately measures for protection of economic elements (in first turn of population) and environment, which presuppose the following actions:

- operative collection and systematization of information about the size of emergency situation, regular updating of this information;
- putting into readiness a special emergency management body;
- preliminary assessment of situation in disaster zones, warning of public about a disaster;
- carrying out of works on operative protection and rescue of people in affected zones;
- mobilization of internal and foreign material and financial resources for rendering help to the victims.

Operative data collection and systematization on the size of emergency situation supposes to establish timely and permanent function of observance and control networks regarding appearance and force of influence of possible destabilizing and affecting factors, equipped with the required equipment, cars and communications.

The received information from them has to be processed and analyzed on analytical centers of district and republican size. Functions of these centers are carried out by the Department of Civil Protection and Emergency Situations and its district sub-units.

Specialized body for emergency management fulfills preliminary assessment and data updating about the situation in the affected zones, warns the population about the disaster, manages operations on protection and rescue, carries out rehabilitation works, administrates material and financial resources which are in reserve, form the budget and coming throng humanitarian aid channels.

Emergency management body depending on the size of the disaster, type and specifics of work for protection, rescue and rehabilitation, should have capacity to grow and change its structure and functions while keeping the general management principles. For a successful work of such a body it is necessary flexible automatic data collection, systematization and processing about continuously changing situation in disaster zones; about decisions taken, available and using specialized units and implemented works on operative protection and rescue; about the size of damage; about available, used or coming material and financial resources regarding coming and directions of expenditures; about the volume of fulfilled rehabilitation works, etc. This system is elaborated and can be organized on a basis of computers of the Department of Civil Protection and Emergency Situations, Government Chancellery, Ministry of Economy and other ministries and Departments.

For carrying out of works on operative protection and rescue it is necessary to have trained and equipped with all required specialized units, that can be put fast in readiness and introduce in disaster zones.

As it can be seen from the diversified chain of possible undesirable phenomena described in the first chapter concrete emergency situation can be significantly differ for the forecasted one and depends on influence of primary phenomenon, a lot of incidents, as well as timely interference of specialized units and volunteers. That is why it is difficult to forecast the type and quantity of necessary forces to be involved in mitigation in disaster zones when one and another emergency situation appears. Nevertheless, on the basis of more hard possible scenario of event development maximum forces and means can be identified to carry out protection and rescue works designed for prevention of undesirable event development.

To determine the quantity of trained people equipped with all required and their maintenance in working conditions of units in order to use them operatively o carry out operations of protection and rescue in disaster zones when such disasters appear fulfill the following calculations and expert assessment:

- a diversified chain of possible undesirable phenomenon, size and action zones are determined for maximum possible activation of each primary source of destabilizing and affecting factors (natural disasters, accidents, catastrophes);
- scenario of possible phenomenon development without interference of specialized units for carrying out of operative protection and rescue operations and with their interference is designed on the basis of diversified undesirable phenomenon chain;
- a possible additional loss is determined because of non-fulfillment of protection and rescue protection , if this loss is significant the following calculations are done in contrary case they are not done, operations on protection and rescue are unnecessary;
- list and order of operations on protection and rescue are estimated, volume and rational terms of commencing and end of these works;

- number and equipment of required specialized units, requirements in material and financial resources for providing activities, as well as reserves of these resources for implementation of these works in disaster zones (including in reserves for rendering help to population with food, cloths, first necessity objects, etc.) are assessed.

A maximum requirements in each type of specialized units and resources are determined out of many variants of requirements in specialized units and resources calculated for scenarios designed for maximum possible activation of each primary source of destabilizing and affecting factors. This result is sought for requirement in specialized units and resources.

Depending on the size of disaster, volume of expected works on protection and rescue, required terms of implementation, separate specialized units can be of local, district and republican importance or have structural sub-units of different levels. Mentioned assessment and calculations are done under the supervision and with participation of the Department of Civil Protection and Emergency Situations.

Specialized emergency management body introduce in disaster zone only those units and in quantity required for a concrete situation.

Thus, for instance, in case of flood such protection and rescue measures as evacuation of population and material values out of zone of and their accommodation in safety places; emergency construction of temporary protective dams, pass-by canals, search and rescue of victims on water, rendering of first medical assistance to victims, proving of them with temporary houses, food, water, first necessity objects; carrying out of anti-epidemiological measures (search and burying of dead people, disinfection of water sources and places of high density of population and animals), etc. can be carried out as protection and rescue operations. In case of a strong earthquake such work as cleaning of obstructions (blockages) , taking out of them of victims and dead people; evacuation of victims, rendering of first medical care, proving them with all necessary; subduing of fires, emergency repair of systems of gas, water and energy supply and sewage; repair of damaged bridges and roads, building up of temporary by-road; emergency strengthening of damaged dams on water reservoirs; carrying out of emergency work for preventing explosions, chemicals and radioactive substances discharge, etc. can be carried out. In case of destruction oh big water reservoirs as a result of earthquake works for catastrophic floods can be implemented as well as other works. The listed works are designed for rescuing of people and material values , carrying out of operative measures to localize spreading of destabilizing and affecting factors.

In case of a big disaster and lack of available resources for carrying out of required works emergency management body (district and republican level) can address the population of the republic, pubic authorities, other countries asking for non-reimbursable material and financial assistance to victims (including assistance or implementation of rehabilitation works). For such cases there is a need to have a list of organizations, responsible for collection, keeping and distribution of assistance to population.

2.8. Training of population, economic agents and public authorities

For training of population, economic agents and public authorities methods of planning of measures to fight against disasters, accidents and catastrophes and actions in emergency situations special curricula are elaborated for teaching in schools, professional schools and high schools, on the courses on civil protection. Training of public authorities of different levels is carried out on the courses on civil protection, on special exercise s on object, district, branch and republican size, where training scenarios of activation of primary destabilizing and affecting factors are played, possible emergency situations that can appear are analyzed, required measures of authorities responsible for emergency management and actions of

specialized units, measures are elaborated, which after putting the into operation can mitigate or prevent undesirable consequences during a real activation of hazard sources.

Curricula are elaborated under the supervision and with participation of the Department of Civil Protection and Emergency Situations. For elaboration of curriculum and carrying out of training required financial resources are allocated from the state budget.

2.9. Rehabilitation

Simultaneously with the carrying out of measures on protection and rescue of people, as well as later an assessment of material losses is done, necessary material, financial and human resources are calculated for fulfilling of necessary full-size rehabilitation works, real possibilities for implementation of these works, executors, sources of financing are assessed, rehabilitation plan is elaborated and after that this work is commenced. Very important for carrying out of rehabilitation works is to have construction materials, machinery, equipment and financial resources on the state reserves.

The volume of state reserve is determined according to the following procedure:

- for scenario of maximum possible activation of each primary sources of destabilizing and affecting factors expected consequences, costs of rehabilitation works and requirements in construction materials, machinery, equipment for carrying out of these works are assessed.
- for each type of construction materials, machinery and equipment out of required quantity in examined scenarios the most important, which with the exception of those which can not be stocked are stoked in the state reserve in a volume of 20% from the highest requirements;
- reserve of financial resources is determined as difference between the costs for rehabilitation for scenarios with the highest volume of rehabilitation works and costs of construction materials, machinery and equipment required for carrying out of these works and kept I the reserve.

3. Elaboration and planning of activities

To realise activities' elaboration and planning procedures it is necessary to suppose of methods of assessment in numbers of danger degree of sources of undesired phenomena, as well as methods of possible material and human losses calculations in case of danger courses stirring up, and methods of efficiency assessment for separate and complex measures.

3.1. Assessment of a hazard degree of possible disasters, accidents and catastrophes

To compare between each other different sources destabilising and damaging factors in terms of their peril for the republican environment, economy and population the following danger assessment criteria based on standardising of sources' characteristics in comparison with typical undesired phenomenon is used:

$$Wi = (Pi/Pm) * [L1*(Si/Sm) + L2*(Di/Dm) + L3*(Ni/Nm)], \quad (3.1)$$

where

Pi - is probability (frequency) of appearance of the i-type dangerous phenomenon which is identified with the help of the data available about similar phenomena, having taken place earlier or with the help of professionals' expert assessment (calculations);

Pm - probability of occurrence of a typical dangerous phenomenon, leading to emergency situation on the local scale (characterised by environmental damages on the territory 1.5 ha, material losses of 21 thousand US$, lethal and medical losses of population not less than 3 persons). This probability is assumed to be equal 10^{-3} or 0,001 (according to the decision of the government or a competent international organisation another occurrence probability of a typical dangerous phenomenon can be adopted);

Si - forecasted average territory of dangerous damage (pollution) of environment (in ha);

Sm - territory of dangerous environmental damage (pollution) caused by a typical dangerous phenomenon stirring up. Sm = 1,5 ha;

Di - forecasted material losses (in 1.000 US$) caused by stirring up of an i-type dangerous phenomenon;

Dm - material losses caused by stirring up of a typical dangerous phenomenon. Dm = 21.000 US$;

Ni - forecasted population losses (lethal and/or medical) caused by stirring up of an i-type dangerous phenomenon (persons);

Nm - population losses caused by stirring up of a typical dangerous phenomenon. Nm = 3 persons;

L1, L2, L3 - weight ratios

If the weight ratios L1=1, L2=1 and L3=2 are assumed to be standard, where priority is given to population protection, then the formula (3.1) will look in the following way:

$$Wi = (Pi/Pm) * [Si/Sm + Di/Dm + 2 \quad (Ni/Nm)] \qquad (3.2)$$

From the formula (3.2) we can see, that if the index of the criteria Wi is over or equals 4, then the i-type source of danger, being analysed, can provoke an emergency situation of the local or higher scale. Thus appropriate organs of power and local authorities have to work out and introduce mitigation measures to prevent possible undesirable development of events.

Summary meaning of the danger criterion in case of several danger sources of similar nature is calculated with the help of the following formula:

$$Wi = \Sigma Win,$$

$$n \varepsilon Ri$$

where

Win - meaning of the danger criteria of a "n" source of "i" type;

Ri - multitude of similar "i" type danger sources.

The table 3.1 gives examples of danger criterion meanings, calculated with the help of the (3.2) and (3.3) formulas for several types of sources of destabilising and affecting factors, that can cause emergency situations of different scales. First four types of danger sources given in the table are single and danger criterion is calculated with the formula (3.2). The fifth type - car accidents is calculated with the formulas (3.2) and (3.3) as result of summary action of 40.000 vehicles that in average participate daily in traffic on the roads of the republic (in 1994 2.746 bad car accidents were registered. Material losses after these amounted to 28 million US$, 3514 persons were injured, including 514 killed. This amount of accidents per 40.000

vehicles moving every day along the roads coincides with probability of an accident $6,9*10^{-2}$, where 1,28 persons are injured and material loss of 4,2 thousand US $ is invoked per accident). Danger criterion for one participant of traffic is calculated with formula (3.2) and equals 72,7 that is considerably higher than criterion for one type o danger. Summary danger criterion for 40.000 vehicles, calculated with the formula (3.3) is given in the table 3.1. Thus, car accidents in general represent the same danger as the strongest drought and are more dangerous than catastrophic floods.

Accidents on auto-transport are a classical example, when for reducing their danger degree significant capital investments to improve the road networks. On a certain stage of development, this situation is accepted as inevitable because of lack of financial resources. In such cases in order to compensate at least a part of the material losses, partial insurance of transport is used. A similar situation can be observed in aviation. In developed countries together with toughening of the security requirements during flights, both insurance of transport and passengers are practiced.

Anti-hail protection and insurance of harvest from hailstorms can serve as an example of a mixed use of measures for mitigation of hazard sources and insurance.

In many cases insurance companies are interested in funding protective measures in order to reduce the expenditures for compensation of possible losses.

Calculation of danger criterion meaning for the complex of sources of destabilising and affecting factors which, despite location of these sources, can influence some certain territory (towns, cities, regions, municipality, republic, group of countries) is carried out with the following formula:

$$W = \sum_{i \varepsilon Ri} Wi \qquad (3.4)$$

where R - multitude of types of sources of destabilising and affecting factors, that can stir up and influence the considered territory;

Wi - meaning of the danger criterion of the "i" type source, calculated for the considered territory.

The formula (3.4) works if only characteristics of consequences (caused by danger sources' stirring up) for the considered territory are taken into consideration and if independence of anger sources' activities is assumed.

Specific danger degree of living on this territory is calculated but means of subdivision the meaning of danger criterion for the complex sources W by the space of this territory So, given in square kilometres.

The table 3.2 demonstrates an example of calculation of the danger degree criterion for a complex of destabilising an affecting factors that can influence the territory of the city of Tiraspol. They are based on the expert data.

On the territory 91 square kilometres specific degree of danger of living on the territory of this city equals 1826 units or 456,5 typical dangerous events per 1 square kilometre of the city territory.

Table 3.1.

Examples of calculation of danger degree criterion for destabilizing and affecting factors based on expert data

Name of source, caused phenomena	Probability of source activation	Number of sources	Consequences characteristics of one source activation			Summary meaning of danger criterion
			Forecasted territory of environment pollution	Forecasted material losses, thousand US $	Forecasted human losses, persons	
1	2	3	4	5	6	7
Dam failure at the hydrological power station in the city of Dubasari, catastrophic floods in the basin of the Nistru river	10^{-4}	1	69823	1260000	6900	11114,5
Activation of an earthquake source in the Carpathian mountains with an intensity of 9 degrees in the epicentre; on the territory of the republic with an intensity from 8,5	2.10^{-2}	1	48,5	900000	900	869530

to 6,5 degrees.						
Accident at the Chisinau water purification plant; contamination of environment with chlorine.	10^{-3}	1	4275	250	4645	5958,5
Droughts, losses of yields and livestock.	10^{-1}	1	0	450000	0	2142857
Accidents on auto-transport; damage of rolling-stocks, material means, human losses.	$6,9*10^{-2}$	40000	0	4,2	1,28	2906280

Table 3.2.

Example of calculation of danger degree criterion for a totality of destabilizing and affecting factors for the city of Tiraspol

Name of source, caused phenomena	Probability of source activation	Number of sources	Consequences characteristics of one source activation			Summary meaning of danger criterion
			Forecasted territory of environment pollution	Forecasted material loss, thousand US $	Forecasted human losses, persons	
1	2	3	4	5	6	7
Dam failure at the Dubasari hydroelectric power station, catastrophic flooding of the city.	10^{-4}	1	400	4200	144	56,3
Activation of an earthquake source in the Carpathian mountains with an intensity of 9 degrees in the epicentre; on the territory of the city with an intensity of 6,5 degrees.	2.10^{-2}	1	0	150	0	142,8
Accidents at the old water dam in	10^{-3}	1	202	25	3645	3777,9

Tiraspol, 1 Moldivizii str.; contamination of environment with chlorine						
Accidents at the new water dam in Tiraspol, Gorplavni str.; contamination of environment with chlorine.	10^{-3}	1	202	25	3645	3777,9
Accident at the third water supply unit in Tiraspol, 9, Sitov str.; contamination of environment with chlorine.	10^{-3}	1	202	25	3645	3777,9
Accident at the sewerage station in Bender, contamination of the Nistru river with chemical and bacteriological substances.	10^{-3}	1	0	0	200	133,3
Droughts, losses of yields and livestock.	10^{-1}	1	0	420	0	2000
Hails; damage of	10^{-1}	1	0	480	0	2285,7

agricultural plants, roofs.						
Spring frosts, damage of a part of yields.	0,3	1	0	240	0	3428,6
Landslides, damage of a part of agricultural lands, buildings and constructions.	-	-	-	-	-	-
Icing of electrical transmission wires, worsening of communication, increase of accident rate, break of electrical transmission wires.	$2*10^{-1}$	1	0	153	0	1457,1
Accidents on the Iujno-Ukrainsk nuclear power station, hazardous contamination of the ground with radioactive substances.	10^{-6}	1	9100	120000	2055	13,2
Accidents on auto-	$6,9*10^{-2}$	2000	0	4,2	1,28	145314

transport; damage of rolling-stocks, material means, human losses.						
Total in Tiraspol						166164,7

3.2. Calculation of possible consequences of activation of hazard sources

The initial data for calculation are results of modeling of hazard sources behavior (data about force, direction,, speed of spreading and degrees of attenuation of destabilizing and effecting factors, data on probability and influence of these factors on concrete parts of territory), data o degree of economic elements and environment vulnerability during influence of thse factors on them of different degrees (degree of damage and probability of appearance of such damages), information about location and number of population, location and economic characteristics of buildings, constructions, industrial enterprise, other objects, about characteristics of environment on a certain territory.

Calculations also take into account damage (losses) from possible appearance and development of secondary undesirable phenomenon. Thus, for instance, calculating consequences of the earthquake in the city of Cahul with an intensity from 8 to 8,5 degrees it is taken into account that with a certain probability destruction of Cahul can factory would occur with a discharge of 20 tones of ammonium, that can cause human losses o 160 people, including dearth of 60 people, destruction of water purification installations with a discharge of 5 tones of chloride would take place, that can cause environment pollution on a territory of 202 hectares and forecasted human losses of 3650 people, including death of 1280 people. In buildings and on enterprises, which have been affected by the earthquake with strong or complete destruction fire can occur, that can cause additional material and human losses, it would make difficult carrying out of rescue works. According to the experience of other countries regarding earthquakes appearance of fires on each site is approximately equal to 0,06. Fires on fire-hazardous sites can cause explosions with a probability of one, which would cause additional material and human losses, etc.

3.2.1. Submitting of information and data on influence of destabilizing and affecting factors

The most convenient for calculation is parameters of destabilizing and affecting factors as force intervals, with which they influence on each part of area of county, city, district, municipality, republic and probability of such influence. For example, 9 degrees in the epicenter of a earthquake in the Carpathians (Vrancea region) - is a phenomenon with a probability of appearance of $2*10^{-2}$ - intensity of the earthquake in Cahul district can be set in a form of 3.3., in which on the basis of data of the map of seismic zonation (see fig. 3.1) is set one of the intervals of influence with a probability of one.

Table 3.3.

Expected earthquake intensity on the territory of Cahul district during an earthquake of 9 degrees in the epicenter.

Intervals of earthquakes' intensity	up to 5	from 5 to 6	from 6 to 6,5	from 6,5 to 7	from 7 to 7,5	from 7,5 to 8	from 8 to 8,5	from 8,5 to 9	more than 9
Ordinal number of intervals	1	2	3	4	5	6	7	8	9
Probability	0	0	0	0	0	0	1	0	0

By analogy characteristics of influence of earthquakes (distribution of probability of influence of respective intervals of intensity) are set for the territory of each district or part of its territory.

Hail storms with hard an medium consequences on the territory of the republic are observed every year, i.e. probability of appearance of such phenomenon on the territory of the republic or equal to one. In this case characteristics of influence of hail-storms are set as share of areas of the covered territory with hails, that cause different degree of heaviness of consequences. For the conditions of the republic on more or less efficient functioning of anti-hail service the force of influence of hail storms can be demonstrated with the data from table 3.4.

Table 3.4.

Expected annual influence of hail storms on the territory of the republic

Force of hail-storms	Absence of hailstorms	Hailstorms that do not cause harvest losses	Hailstorms with medium consequences	Hailstorms with heavy consequences
Ordinal number of hailstorms' force	1	2	3	4
Part of covered territory of the republic	0,93	0,01	0,04	0,02

Hailstorms of medium heaviness cause 50% losses of harvest, and those of heavy consequences cause loses of harvest, damage of roofs and windows of houses, destruction of green-houses, etc.

At the same time, on the territory of certain districts (neighboring to the border of Romania) hailstorms are more probable, but on the territory of others (neighboring to Ukraine), are less probable. For instance, for Cahul district according to data of multi-annual observations information about force of hails' influence on its territory can be demonstrated in a form of table 3.5.

Table 3.5.

Expected annual influence of hails on the territory of Cahul district.

Force of hailstorms	Absence of hailstorms	Hailstorms that do not cause harvest losses	Hailstorms with medium consequences	Hailstorms with heavy consequences
Ordinal number of hailstorms' force	1	2	3	4
Part of covered district's territory	0,9	0,02	0,05	0,03

Data, presented in table 3.5, about shares of areas of districts covered by hailstorms for each farm is indicators of probability of hail influence of different degree on its territory. These data can be used for calculation of medium expected losses, for justification of necessity of harvest insurance, etc.

For sites, on which there is hazard of discharge of chemicals and radioactive substances, hazard of catastrophic floods and other influence on economic elements and environment during accidents zones of possible spreading of respective affecting factors are calculated (according to elaborated and adopted models and methodology), and later data about shares of areas of these zones are determined, covered by force of influence of these factors with

different intervals (in each case the whole territory of zones can be covered by equal force of influence).

3.2.2. Submitting of data on the vulnerability of economy and environment

As it have been mentioned in chapter II, data about vulnerability of economic elements (including population) and environment are gotten out of the analysis of consequences of a eal influence on them of respective destabilizing and affecting factors, as well as engineering calculation by analogy or by experiment.

The same by parameters economic elements and environment are not uniform influenced by physical aging, previous affecting factors, conditions of local activation of affecting factors (for instance, high level of underground water increase the intensity of earthquake in separate points of the territory) and other conditions. Thus, the characteristics of vulnerability are demonstrated in tables or graphics with indication of probability of getting of respective damages or interruption in functioning of these elements depending on the force (force intervals) of influence of the concrete destabilizing or affecting factor.

An example of submitting of data about vulnerability of buildings of different types depending on the earthquake intensity intervals is given in table 3.6.

Table 3.6.

Dependence of buildings' damages of different type from earthquake intensity intervals

Type of buildings	Earthquake intensity intervals in degrees	Ordinal number of intervals	Part of buildings that are getting damaged					
			no damages	small	medium	hard	destruction	collapse
1	2	3	4	5	6	7	8	9
Wattle and daub houses, torn stones on clay mortar	5-6	1	0,55	0,38	0,07	0	0	0
	6-6,5	2	0,08	0,23	0,38	0,23	0,08	0
	6,5-7	3	0,06	0,15	0,24	0,4	0,15	0
	7-7,5	4	0,04	0,08	0,12	0,42	0,28	0,06
	7,5-8	5	0,03	0,04	0,08	0,27	0,43	0,15
	8-8,5	6	0,02	0,03	0,05	0,16	0,4	0,34
	8,5-9	7	0,02	0,03	0,05	0,09	0,2	0,61
Type C7. Buildings of anti-seismic construction calculated for 7 degree intensity	5-6	1	0,94	0,06	0	0	0	0
	6-6,5	2	0,78	0,2	0,02	0	0	0
	6,5-7	3	0,51	0,4	0,09	0	0	0
	7-7,5	4	0,32	0,45	0,2	0,03	0	0
	7,5-8	5	0,18	0,35	0,4	0,07	0	0
	8-8,5	6	0,08	0,27	0,42	0,2	0,03	0
	8,5-9	7	0,06	0,19	0,27	0,4	0,08	0
Type C8.Buidings of anti-seismic construction calculated for 8 degree intensity	5-6	1	1	0	0	0	0	0
	6-6,5	2	0,94	0,05	0,01	0	0	0
	6,5-7	3	0,84	0,15	0,01	0	0	0
	7-7,5	4	0,69	0,28	0,03	0	0	0
	7,5-8	5	0,5	0,42	0,08	0	0	0
	8-8,5	6	0,32	0,45	0,2	0,03	0	0
	8,5-9	7	0,17	0,35	0,4	0,08	0	0
Type C9. Buildings of	5-6	1	1	0	0	0	0	0

anti-seismic	6-6,5	2	0,98	0,02	0	0	0	0
construction	6,5-7	3	0,92	0,08	0	0	0	0
calculated for 9	7-7,5	4	0,87	0,12	0,01	0	0	0
degree intensity	7,5-8	5	0,81	0,17	0,02	0	0	0
	8-8,5	6	0,68	0,26	0,06	0	0	0
	8,5-9	7	0,5	0,42	0,08	0	0	0

For each building data in table 3.6 represent probability that it will be proved in case of that earthquake intensity interval.

Material loss to building (together with equipment in it) depending on the degree of damage, will be 3 % of its cost in case of small damages, 10% - in case of medium, 25% - hard, destruction - 70%, collapse - 100%.

Part of human losses which are in the building during earthquake is assessed in the table 3.7.

Table 3.7

Part of human losses which are in the buildings during an earthquake

Type of human losses	Part of human losses in case of damaging of the buildings					
	No damages	Insignificant	Moderate	Heavy	Destruction	Collapse
General	0	0	0,04	0,08	0,25	0,98
Irretrievable	0	0	0	0,03	0,05	0,52

By analogy there is presented data about vulnerability of economic facilities and environment during influence of other type of destabilizing and affecting factors.

3.2.3. Consequence of calculations of hazard source activation

Results of calculations are: area of hazardous damages (pollution) of environment, expected material loss, possible human losses.

Mathematical expectation (average meaning) of damaged area (pollution) of environment, which can occur during activation of the respectetive i-type hazard source, is determined on the basis of the analysis of a chain of possible undesirable phenomena caused by this source and is calculated by this formula:

$$Si = Soi + \sum_{l \in R} Pl * Sol, \qquad (3.5)$$

where

Soi - maximum area of hazardous damage (pollution) of environment, caused by affecting factors of the primary hazard source of i-type during its activation*);

Pl - probability of activation of secondary hazard sources of each l - type in the chain of undesirable phenomena, provoked by the action of affecting factors of the primary source of i-type. The example of calculation of these probabilities is presented below;

R - a lot of possible types of secondary hazard sources;

Sol - maximum area of damage (pollution) of environment, caused by affecting factors of he secondary hazard source of l-type during its activation influenced by affecting factors of previous hazard sources (according to the chain of undesirable phenomena).

*) Hazard source, as a rule, has one affecting factor, for example, earthquake center, cause soil vibration of a certain intensity, catastrophic flood - pressure of the breaking wave etc., but some hazard sources can have several affecting factors (accident on a fire-hazardous enterprise) can affect by the blast, light radiation of fire, discharge of strong poisonous substances and toll-products). That is why, the maximum area of hazardous damage (pollution) of environment) is determined taking into account all factors of the hazard source.

Calculation according to formula (3.5) gives only approximate result because it does not take into account possible crossing of areas of damage (pollution) of environment by factors of different secondary hazard sources, but, in view of the fact that there is a small probability to appear secondary affecting factors (from 0,05 to 0,3), the calculation error is insignificant (no more than 10%) and the calculation results are good for practical use.

We can make a calculation with the help of formula (3.5) on a conventional example of an earthquake. During earthquake of 9 degree intensity in the epicenter (Vrancea region) soil vibration on the whole territory of the republic practically would not cause damages (pollution) of environment. Therefore, area Soi for this hazard source is accepted as equal to zero (i=1). But an earthquake with a certain intensity on a concrete territory can cause a chain of secondary phenomena - discharge of strong poisonous substances during destruction of industrial facilities, fires in obstructions of collapsed buildings, landslides, etc. As it can be concluded form table 3.6 the buildings of C7 type during an earthquake of 8-8,5 degree intensity can get hard damages with a probability of 0,2 and destruction with a probability of 0,3. Under (In the time of) such degrees of damages of the Cahul can factory and water purification installations in the city of Cahul , the ammonium and chlorine will be discharged in the atmosphere. The probability of appearance of such events in accordance with the above mentioned will be equal to P = 0,2 + 0,03 = 0,23. Accordingly to the table 3.3 the probability of an earthquake of 8-8,5 degree intensity in the city of Cahul is equal to one. Mathematical expectation of probabilities of discharge as a result of an earthquake of ammonium (P2) and chlorine (P3) will be equal to

P2 = P3 = 1 * 0,23 = 0,23.

The maximum possible areas of environment pollution, caused by the accidents on these two facilities will be respectively 9 and 202 hectares, and total losses of population will be 156 and 3645 people. Mathematical expectations (average meaning) of areas of environment pollution and human losses as a result of accidents on the above mentioned facilities will be:

S = P2 * So2 + P3 * So3 = 0,23 * 9 + 0,23 * 202 = 48,5,
N = 0,23 * N01 + 0,23 *N02 = 0,23 * 156 + 0,23 * 3546 = 874 people.

The results obtained above of calculation are included in the total data of assessment of the earthquake's consequences (see table 3.1).

The expected material and human losses are determined in the following order:

- quantity and costs of economic facilities of one type of vulnerability characteristics situated on this territory (for example, quantity of buildings and constructions of one type regarding seismic resistance, costs of material values and number of population situated in and around them; area of agricultural plants by their types; quantity of agricultural animals by their types, etc.);
- the size of the possible material and human losses is calculated on the basis of data about quantity of standard economic facilities and population, of data about vulnerability by the respective affecting factors in hazard zones.

Quantity and costs of economic facilities of one type regarding vulnerability characteristics and number of population situated on the concrete hazard zones are determined by summing up of quantity of these facilities and population, living in the settlements on this territory.

The expected material damage in calculated by formula:

$$Di = \sum_{n \varepsilon L} Dni \qquad (3.6)$$

where

Dni - total material damage, which can be caused to n-number of total one type economic facilities regarding vulnerability characteristics during primary hazard source activation of i-type secondary hazard sources and related to them;

L - many examined aggregates of one type economic facilities.

The size of Dni is determined in the following way:

$$Dni = Doni + \sum_{l \varepsilon R} Pl * Donl, \qquad (3.7)$$

where

Doni, Donl - total material loss, which can be caused to n-number of the aggregate one type economic facilities during direct activation of i-type primary or l-type secondary hazard sources;

Pl - is described in formula (3.5).

Total material loss, which can be caused to n-number of the aggregate of one type economic facilities during activation of i-type primary or other l-type secondary hazard source can be calculated by formula:

$$Donk = Qn \left[1 - \prod_{t=1}^{Tk} (1 - Ynkt)\right], \qquad (3.8)$$

where

Qn - costs of the aggregate of economic facilities of n-type and material values, situated in them;

Tk - quantity of the simultaneously functioning of affecting and destabilizing factors of k-type hazard source (k=i or k=1);

Ynkt - mathematical expectation of a part of material loses of economic facilities of n-type in relation to their costs before damage after influence of t-type affecting factor of k-type hazard source.

Mathematical expectation of a part of economic facilities losses of each n-type influenced by t-type affecting factor of k-type hazard source (primary or secondary) is calculated in the folowing way:

$$Ynkt = \sum_{r=1}^{Lkt} Pktr * \sum_{f=1}^{Fn} bnktrf * Bnf. \qquad (3.9)$$

where

Pktr - probability of coverage of territory where objects of n-type are situated by r-type interval of force of influence of t-type affecting factor during k-type hazard source activation (or part of area of this territory covered by r-type interval of influence force of respective affecting factor) which is presented as data in tables 3.3, 3.4, 3.5;

Lkt - maximum number of gradation of force of t-type affecting factor of k-type hazard source;

bnktrf - part of n-type economic elements, which get f-type degree of damage (see, for example, data of table 3.6) during their getting into th r-type interval of influence force of t-type affecting factor during activation of k-type hazard source;

Fn - maximum number of gradation of degree of damages (destruction) accepted for n-type economic elements;

Bnf - damage caused to n-type economic elements in parts from their costs (for example, part of damage corresponds to 0,03 from costs of buildings with small damage during earthquake; with moderate damage - 0,1; hard - 0,25; destruction - 0,7; collapse - 1).

Hereinafter it is considered a conventional example of material damage calculation, which can be caused to buildings and constructions with characteristics presented in table 3.8 and situated in earthquake zone with intensity from 8 to 8,5 degrees (see table 3.3).

Table 3.8.

Example of calculation of expected material loss in earthquake zone with intensity of 8 to 8,5 degrees

Type of building	Quantity pieces	Total cost, in million US $	Mathematical expectation of damage	Material loss, in million US $
A1	3000	30	0,6659	20
C7	39000	487,5	0,1211	59
C9	800	230	0,0138	3,2
TOTAL	42800	747,5	-	82,2

In accordance with the data of table 3.6 during earthquake intensity of 8-8,5 degrees a part of 0,02 of A1-type of buildings will not get any damages,0,03 part will get small damages, 0,05 - moderate, 0,16 - hard damages, 0,4 will be demolished, 0,34- collapsed (if we take into account that buildings of type A1 n=1, type C7 n=2 and type C9 n=3, earthquake index k=1, number of affecting factor of earthquake t=1, number of interval of r-type influence force of earthquake 9 -8,5 degrees accordingly to table 3.3. equal to 7, number of damage degrees of f from 1 to 6, b11171 = 0,02; b11172 = 0,03, b11173 = 0,05; b11174 = 0,16; b1175 = 0,4; b11176 = 0,34). Calculating according to formula (3.9) when P117 = 1 :

$$Y111 = 1 * \left(\sum_{f=1}^{6} b1117f * Bnf\right) =$$

$$= 0,02 * 0 + 0,03 * 0,03 + 0,05 * 0,1 + 0,16 * 0,25 + 0,4 * 0,7 + 0,34 * 1 = 0,6659.$$

As during earthquake there are no other primary affecting factors, besides earthquake intensity, thus the formula (3.8) gets the simplified form:

$$Don1 = Qn * Yn11 \qquad (3.10)$$

For A1 type of buildings the total mathematical expectation of damage will be equal to Y111 = 0,6659, and material loss will constitute:

Do11 = Q1 * Y111 = 30 * 0,6659 = 19,98 million dollars.

By analogy there are calculated mathematical expectation of losses and material damages for C7 and C9 type of buildings, which are introduced in table 3.8.

It is seen in the formula (3.7) that besides damage caused directly by primary affecting factors of earthquake, it is necessary to take into account the damage from the influence of affecting factors of the secondary hazard sources (accidents on chemical plants and fire-hazardous enterprises, etc.). In this example, because of insignificance, we neglect material loss caused by fires and poisonous substance discharge. In this case the total loss, caused by the earthquake (in the examined zone) will be equal only to sum of losses of the first element? Of formula (3.7) and will account for 82,2 million dollars for this example.

Calculation of human losses is done accordingly to analogous formulas (3.6) - (3.9) and are the following:

$$Ni = \sum_{n \in L} Nni, \qquad (3.11)$$

$$Nni = Noni + \sum_{l \in R} Pl * Nonl, \qquad (3.12)$$

$$Nonk = Zn * \left[1 - \prod_{t=1}^{Tk} (1 - Xnkt)\right], \qquad (3.13)$$

$$Xnkt = \sum_{r=1}^{Lkt} Pktr * \sum_{f=1}^{Fn} bnktrf * Bnf \qquad (3.14)$$

where

Ni - human losses (here and hereinafter in people), which can happen during activation of i-type hazard source;

Nni - total human losses, which use protective means of n-type (buildings of different types, shelters, anti-radiation shelters, open places, gas masks, etc.), which can happen during activation of i-type primary hazard source and secondary hazard sources caused by it;

Noni, Nonl - total human losses, which use n-type protective means, which can happen during activation of i-type primary or l-type secondary hazard sources;

Zn - number of population, which use protective means of n-type;

Xnkt - mathematical expectation of human losses, which use protective means of n-type, during influence of t-type affecting factor of k-type hazard source (K=i, k=1);

Pl, Pktr, Tk, Lkt - are described in formulas (3.6) - (3.9);

Fn - maximum number of gradation of damage degrees, accepted for n-type protective means;

bnktrf - part of n-type protective means, which get f-type damage degree (see, for example data of table 3.6) during r-type force interval of t-type affecting factor during activation of k-type hazard source;

Bnf - part of human losses, which use n-type protective means during getting f-type damage degree to these means (see, for example data of table 3.7).

In results of calculation accordingly to formulas (3.11) - (3.14) by using data of the first line of table 3.7 total losses are determined, but by using the data of the second line of the table the irrevocable losses are calculated.

Hereinafter a conventional example of calculation of expected total human losses will be considered, which can happen in an earthquake zone of 8 to 8,5 degree intensity using protective means, presented in the table 3.9.

Table 3.9.

Example of calculation of the total human losses in an earthquake zone of 8 to 8,5 degree intensity

Type of protective means	Number of protective means, pieces	Number of protected people, thousand people	Mathematical expectation of losses	Total losses of population, thousand people
Type of buildings				
A1	3000	7,5	0,4496	3,372
C7	39000	79,5	0,0303	2,409
C9	800	0,8	0,0024	0,002
open place	-	12,2	0	0
TOTAL	-	100	-	5,783

In accordance with the data of the tables 3.6 and 3.7 calculation accordingly to formula (3.14) for A1 type buildings gives:

$$X111 = 1 * \left(\sum_{f=1}^{6} bnktrf * Bnf \right) = 0,02 * 0 + 0,03 * 0 +$$

$$0,05 * 0,04 + 0,16 * 008 + 0,4 * 0,25 + 0,34 * 0,98 = 0,4496$$

By analogy the possible human losses, which at the moment of earthquake are situated in C7 and C9 type of buildings are calculated and the data is introduced in table 3.9. Population, which is situated in an open air, does not get any damages.

If considering scenario of development of a chain of undesirable phenomena, caused by an earthquake, probability of secondary hazard source activation is determined, thus for each of this source the above mentioned calculations for human losses are calculated and data is introduced in table 3.9. The total data regarding losses contained in these tables are multiplied to the respective probability of hazard source activation and the result is add to the data on losses contained in the table 3.9. This procedure actually carry out the complex of calculations according to formulas (3.11) - (3.14). For example, it is determined that during an earthquake of 8 -8,5 degree intensity the discharge of ammonium and chlorine in this zone (as it have been mentioned in example about city of Cahul) is equal to 0,23, human losses

from the influence of hazardous concentration of these substances on the territory of their spreading, the results of calculations are multiplied to probability of such phenomena appearance and are added to the total sum of losses, caused directly by the affecting factor of the earthquake.

The above mentioned calculations are labour-intensive and need a lot of initial data. Therefore, all processes of modeling and calculations, starting from modeling of spreading of affecting factors of hazard sources to concrete calculations of consequences of each hazard source activation should be automated with the use of personal computers.

3.3. Choice and efficiency assessment of measures for combating of disasters, accidents and catastrophes

The most efficient are measures for combating of hazard sources, which the most reduce criterion of danger degree of this source per unit of annual expenditures for their implementation, i.e. which gives the most meaning of the indicator:

$$Ýi\ (g) = \frac{\Delta\ Wi\ (g)}{Cp\ (g)} \qquad (3.15)$$

$$\Delta\ Wi\ (g) = Wi - Wi\ (g) \qquad (3.16)$$

$$Cp\ (g) = Ce\ (g)\ @\ K\ (g) * Eí, \qquad (3.17)$$

where

Wi, Wi (g) - meaning of criteria of danger degree of i-type hazard source without introduction of g-type measure and with its introduction, calculated according to formulas (3.2) - (3.3);

Ce (g) - additional annual operating costs after introduction of g-type measure;

K (g) - required capital investments for implementation of g-type measure;

Eí - normative efficiency ration of capital investments (Eí =0,08).

It should be mentioned that in reality not the most efficient measures according to indicator (3.15) because of economic and other reasons. For example, the most efficient measure in the field of water purification with ozone instead of chlorine, on a certain stage is practically impossible because of the lack of required financial resources or high purification costs. Thus other measures will be planned and undertaken, which will reduce the probability of accidents, etc.

Measures for combating of hazard sources can be conventionally be divided into independent, interdependent, functionally dependent and those excluding introduction of ones during using of others. The analysis shows that the number of independent regarding efficiency criterion (3.15) is very limited. For example, conventionally it can be considered, that provision of personnel working at the chemical hazardous enterprise and population living nearby it with gas masks and measures for evacuation of workers and population are independent form each other, i.e. effect from each measure does not depend from introduction of other , but the total effect is equal to the sum of effects from each measure.

But, the effect of these measures in a certain degree depends on timely warning of workers and population about accident. If warning is not done in time this can depreciate the above mentioned measures. The measures for providing of gas masks and evacuation of population from the zone of accident are functionally dependent from the warning measures. Warning

measure actually is a reason, on which the effect of other two measures depend. Carrying out of rescue, emergency and rehabilitation works in the zone of poisonous substances contamination in accepted terms is impossible without providing of people who carry out of these people with gas masks, medicines, food fuel, and other means. These means reserves themselves have zero efficiency indicators and decrease the economy efficiency, but their lack because of impossibility to get required means from the operating economy, reduce the preparation to the carrying out of rescue and emergency works to a minimum.

There are such measures, the implementations of which exclude the use of other measures. For example, the measures for using of technological process of water purification with ozone instead of chlorine practically do not cause hazardous substances discharge in atmosphere, which in its turn exclude the necessity to prepare measures for population and environment protection near this industrial facility; measures which exclude the location of economy facilities in the catastrophic floods zones ,exclude the necessity to build up protective dams, to carry out measures for warning of population, to evacuate population and material values for these zones, etc.

The effect of introducing of the majority of measures is interdependent. For example, the measures which reduce the probability of activation of the chemical contamination source and the criterion meaning (3.3) by two times (by building up of anti-seismic constructions, setting up of more perfect blockage system of emergency situations, etc.), and measures , which reduce in case of an accident, the area of possible environment pollution, possible human losses and criterion meaning 3.3 by three times (use of more perfect technological process with a considerable reduction of used poisonous substances, etc.) each separately are characterized by equal meaning of efficiency indicator (3.15). Mutual introduction of these measures can reduce the danger criterion by 6 times as well as to reduce joint efficiency indicator by 1,4 times in relation to efficiency indicator of each separate measure. The efficiency indicator of the first measure (which reduce the probability of an accident by 2 times), calculation with a condition that the second measure (which reduce the volume of used poisonous substances) is already introduced and applied, is reduced by three times in comparison with that, when the second measure is not introduced, but the efficiency indicator of the second measure, calculated for the condition, that the first one is already introduced, respectively is reduced by two times. Thus, the effect from the introduction of these two measures is interdependent. Between the effects of the totality of measures can exist more complicated dependencies. The enumerated examples are presented in order to emphasize the necessity to asses efficiency of the measures depending on their combination and sequence of introduction, the necessity of assessing of all minimal totality of the measures that all efforts and expenditures don to be done in vain because of not taking into account any of them, which can be considered insignificant at the careless analysis.

Elaboration and selection of the measures for combating of natural disasters, accidents and catastrophes are done in the following succession:

1. Its is elaborated a scenario (ramified chains of possible undesirable phenomena) of a maximum possible activation of each of the primary sources of destabilizing and affecting factors, territory of possible disaster zones is assessed;
2. On the basis of statistical and scientific data about vulnerability of economic elements and environment for each scenario the possible human and material losses and damage area (pollution) of environment are calculated;
3. Measures for following up of activity of hazard sources and influence on them in order to prevent or to mitigate (reduce) their activity (preventive measures on enterprises, anti-hail, anti-epidemics and other measures) taking into account the achievements of science and technology, recommendations of specialists;

4. The calculations envisaged in points 1) and 2) for taking into account (introduce) the measures elaborated in point 3 are carried out;
5. On the basis of data of point 4) the efficiency of the measures envisaged in point 3) is assessed. If the expected effect from the introduction of measures for preventing or mitigating the activity of the primary hazard sources provides a zero level of danger, in this case a selection of other measures is not done. If the achieved danger level in not higher than the desired one in this case it is passed to point 9), otherwise to point 6);
6. On the basis of the results of scientific research and recommendations of specialists of different branches of economy measures for increasing of resistance (reduction of vulnerability), for timely protection of economic elements and environment from the direct influence of destabilizing and affecting factors expected in case of a maximum possible activation of a concrete primary hazard source with a condition of applying of measures envisaged in point 3) are elaborated;
7. Calculations are carried out envisaged in points 1) and 2) for introduction of measures elaborated in points 3) and 6);
8. On the basis of data contained in point 7) a total efficiency of measures elaborated in points 3) and 6) is assessed. If the expected effect from the introduction of measures for preventing or mitigating the activity of the primary hazard sources provides a zero level of danger, in this case a selection of other measures is not done otherwise it is passed to point 9);
9. The measures are elaborated:

a) to create warning systems for population, public authorities and economic agents about danger in case of activation of primary sources of destabilizing and affecting factors;

b) to create forces and means, which would provide operative protection and rescue of economic elements and environment, as well as to create required reserves of material and financial resources (state, district, local);

c) to create and maintain an emergency management systems on different levels;

d) to create and improve permanently systems for training of population, economic agents and public authorities about actions in case of emergency situations;

e) to create required reserves for carrying out of rehabilitation works.

The required scientific research can be envisaged for carrying out of each measures' selection.

The selected measures for combating of each primary hazard source separately are introduced in a 3.10 type table.

After filling in a table the planners pass to the second stage of measures' selection in order to minimize the expenditures for implementation of measures, aimed at combating of all hazard sources on a certain territory (village, town, district, city, republic).

A part of measures provides a certain effect of resistance to several hazard sources of a same or different types (for example, gas masks provide practically the same protection from discharges of many types of strong poisonous substances as well as from radioactive substances during accidents on different enterprises; building and installations of anti-seismic construction provide increased resistance not only during earthquake but also during hurricanes, catastrophic floods, etc.). Such measures and expenditures for their implementation, calculated for combating of each hazard source separately in the area of crossing of destabilizing and affecting factors spreading are duplicated.

Table 3.10

Measures

(republic, ministry, department, territorial management body (district, municipality, settlement)

for combating _____

(hazard source)

Title of measures (on building up of constructions, purchase and assembling of equipment, devices, systems; on formation of forces, equipped with required material and technical means; on establishment of material and financial resource; on elaboration of normative documents	Unit of measurement	Quantitative indices of measures			Additional costs required		Indices of measures' efficiency
		Required	Applied	Additional ones that should be introduced	Capital costs, in thousand lei	Operating costs, in thousand lei per year	
1	2	3	4	5	6	7	8

I. Follow up of dangerous sources.

The first group of measures includes measures on establishment of a network to observe the activity of danger sources, of data collection, processing and distribution related to this source behaviour (a number of seismic stations are established to follow up an earthquake centre, a network is required to identify and research hail-forming clouds and to fight against hail, a network of sanitary and epidemic stations, etc. is required to fight against epidemics.), on formation of methods and means to forecast possible activation of a danger source.

II. Influence on a source of danger

Herein the measures, which should not allow an activation of a danger source and to reduce destabilising and affecting factors in case of activation (establishment and use of installations for influence on hail-forming clouds with a view of decreasing the size of hails to non-dangerous size in fight against hails; replacement of production technologies by technologies, which exclude the use of dangerous substances; creation and assembling of means and equipment, which decrease a possible elimination of toxic substances in case of disaster, etc.)

III. Decrease of vulnerability of economic, population and environmental elements.

For instance, in case of an earthquake some measures for strengthening seismic resistance of existing buildings, norms for construction of new and reconstruction of old buildings and constructions are elaborated and approved taking into account the seismic resistance standards, a punishment for infringement of these norms is fixed, etc. In case of counteraction to accidents on dangerous chemical sites, stocking and provision of the population with anti-pillboxes, etc.

IV. Early protection.

Herein early measures are included implemented before an activation of danger source and those providing full or partial protection of economy, population and environment from direct destabilising and affecting factors of this source. For instance, construction of buildings on special cushion, which exclude a transmission of soil vibration to the building can be used during counteraction to an affecting factor of an earthquake centre; the population can be provided with shelters and means for individual anti-chemical protection as counteraction to a dangerous chemical source; the destruction of green houses can be avoided by installing certain protection nets; catastrophic flooding can be prevented by construction of by-pass canals and protection dikes, by placing sites beyond zones of possible flooding. Early protection of economy from landslide influence may consist of elaboration and approval of normative documents forbidding construction of buildings and installations in landslide zones, where no measures for landslide prevention are envisaged.

V. Warning about danger. Operative protection and rescue.

According to scenario of disaster development in case of a maximum activation of danger source, following measures are envisaged.
A warning method of population and economic agents, who can be in the zone of destabilising and affecting factors is elaborated, organisational structures and special networks for transmission of information on danger, of informing high management bodies are created, if necessary.
On the basis of elaborated network schedule of possible works related to operative protection and rescue, and the following is identified required to implement these works:

- special units, their number and equipment, expenditures for equipment and maintenance in permanent preparedness;
- reserves of material and financial sources;

- management bodies in case of emergency, providing them with means for operative collection, systematisation and processing of information, expenditures for equipment and maintenance in permanent readiness of these bodies.
- system of training of population, economic agents and management bodies to act in such case of emergency.

VI. Rehabilitation.

Taking into account implementation of measures groups I_V possible material loss is assessed in case of maximum activation of considered source of danger, an expected volume of rehabilitation works, needs in material and financial resources are estimated. On the basis of these data certain measures for creation of reserves of construction materials, trucks, equipment and financial means.

Table 3.11

Measures

(republic, ministry, department, territorial management body (district, municipality, settlement)

for combating natural disasters, accidents and catastrophes (hazard source)

Title of measures on combating one or several hazard sources	Unit of measurement	Quantitative indices of measures			Additional costs required		Source of financing
		Required	Applied	Additional ones that should be introduced	Capital costs, in thousand lei	Operating costs, in thousand lei per year	
1	2	3	4	5	6	7	8

Certain measures have local or specialized character and directly are linked only to combating of each separate hazard source (for example, automate systems for identification and blockage of accidents on concrete chemical or radioactive hazardous plants, warning systems in zones of possible hazardous influence of these affecting factors during accidents of these plants; automated systems for fire extinguish, etc.). Such measures and their quantitative indicators are filled in the respective chapter of measures plan without changes. But there are options for optimization. During planning of such measures all possibilities of using already existing systems should be analyzed.

3.4. Sequence and order of measures planning

Elaborated and selected measures presented in type of table 3.4 represent certain complex of rational measures, which if they are implemented, will give an acceptable level of danger (safety) of living in a settlement, district and group of districts, republic in general.

These complex actually represent goals, which should be tried to attained and can be achieved in a certain period, if from respective sources of financing required monetary means will be allocated.

Period of implementation of selected complex of measures depends on financial possibilities of economic agents - hazard sources, local and republican budgets, normative documents regarding duration of assimilation of capital investments (for instance, a certain construction in accordance with technological process can not be built up in two or more years, etc.), on accepted consequence of measures implementation (necessary equipment can not be fix up prior to building up of premises for them etc.).

For changing tables of type 3.11 into long-term plans or programmes it is necessary that specialists in this field of planning assess and coordinate with the holders (owners) of financial sources the possibilities and real volume of allocated source in each of the following years with a view of determining of a minimal period of implementation of selected complex of measures.

Respective (on the level of settlement, district, republic) plans (programmes) for implementation of measures for combating of natural disasters, accidents and catastrophes are composed taking into account the above mentioned limitations (limitation of allocated financial resources in each year, normative documents of assimilation of capital investments for each measure, accepted order of measure implementation).

These plans (programmes) are presented in tables like 3.12 with required explanatory notes to them. Indicators of column 6 to (au@7) of table 3.12 are presented in a form of fraction. Numeral indicates the volume of capital investments, denominator - volume of annual of operating costs.

Table 3.12

Plan of measures implementation

(republic, ministry, department, territorial management body (district, municipality, settlement)

for combating natural disasters, accidents and catastrophes for _____ years

Group of measures, measures for combating one or several hazard sources	Unit of measurement	Quantitative indicators of measures			Costs (in thousand lei)/operating costs (in thousand lei annually)					Source of financing
		Required	Applied	Necessary to be additionally introduced	Total for the period of planning	including by years				
						first	second	.....	last au	
1	2	3	4	5	6	7	8	.....	au@7	au@8

In the process of elaboration of long-term plans (programmes) there are taken into account the following priorities of allocation of financial resources:

- on the certain territory in the first turn there implemented measures for combating hazard sources with the highest indicators of danger;
- in the first turn there are implemented that complex of measures, which lead to the reduction of hazard degree on the territory with the higher indicators with a view of leveling of hazard degree on the whole territory of the country;
- for each year there is planned that volume of measures, the costs of which allow to implement them in normative terms of capital investments assimilation.

Taking into account the high tempo of development of modern science, technology, the long-term plans (programmes) for combating natural disasters, accidents and catastrophes are periodically revised and specified.

Out of long-term plans annually are taken out measures, which are necessary to implement in the next year and on this basis annual plans are composed in a form of tables of 3.13 type and explanatory notes to them.

Measures for combating of hazard sources which can cause emergency situations of local size are planned by local public authorities. For planning and implementation of measures there are involved managers and specialists from the territory where these enterprises or organizations are situated.

Plans for combating hazard sources of local size are approved by district (municipality) public authorities bodies and are implemented on the account of financial resources of enterprises - hazard sources (explosion-, fire- and chemically hazardous enterprises; enterprises situated in a landslide zones; facilities which represent a danger of bacteriological contamination, etc.) and local budget. Implementation of a part of measures can be funded from the district budget.

Table 3.13

Plan of measures implementation

(republic, ministry, department, territorial management body (district, municipality, settlement)

for combating natural disasters, accidents and catastrophes for _____ years

Title of measures on combating one or several hazard sources	Unit of measurement	Quantitative indices of measures			Additional costs required		Source of financing
		Required	Applied	Additional ones the should be introduced	Capital costs, in thousand lei	Operating costs, in thousand lei per year	
1	2	3	4	5	6	7	8

Measure for combating of hazard sources that can cause emergency situations of district size are planned by district (municipality) public authorities with involvement of managers and specialists of enterprises - hazard sources and local public authorities (municipality) on the territory, where these enterprises are located. These planes are coordinated with the Department of Civil Protection and Emergency Situation, Ministry of Finance, Ministry of Economy, other interested public authorities of republican level and are approved by a decision the government of the republic. Implementation of measures are funded from district (municipality) budgets and on the account of enterprises - sources of hazard. Implementation of a part of measures can be funded form the republican budget and included in the plans of measures of republican level by a decision of the government of the republic.

The measures for combating of hazard sources, which can cause emergency situations of republican and interstate sizes are planned and approved by the republican government. Elaboration of a draft plan of measures is organized and coordinated by the Department of Civil Protection and Emergency Situations with an involvement of ministries and departments of the republic, district (municipality) public authorities, scientific and research institutes, internal and international experts, as well as enterprises, where accidents can cause emergency situations of republican and interstate size. Department of Civil Protection and Emergency Situation also conclude and implement agreements with the neighboring countries on common planning and funding of measures for combating hazard sources, which can cause emergency situations of international size. Planned measures on republican and interstate levels are funded out of the republican budget, as well as out of the enterprises - hazard sources.

Activation of the primary hazard sources of the same or different type, as a rule, does not depend form each other and probability of their simultaneous action is very insignificant. Thus, as it is mentioned in the second chapter, timely preparation of resources (human, material, technical, financial) for operative protection and rescue, implementation of rehabilitation works should be done (with a view of costs minimizing) with a condition to be ready for efficient combating of one hazard source with a highest activation on this territory. Proceeding from these conditions numerical meaning of indicator of each necessary resource, which cover the requirement for combating of each one hazard source, is determined as a maximum meaning out of multitude of required meanings on all possible hazard sources. For example, if for rehabilitation works during earthquake relief it is required 135 thousand of asbestos-cement , heavy rains with hails and hurricanes - 210 thousand, maximum requirement will constitute 210 thousand of asbestos-cement, the reserve will have 20% of these requirements, i.e. 42 thousand of asbestos-cement, but financial requirements for these purposes will be equal to the sum of lacking asbestos -cement, i.e. 168 asbestos-cement.

Calculated numerical meaning of indicators of measures and costs for their implementation are introduced in table of 3.11 type, which is a result of draft variant of measures for combating of all types of natural disasters, accidents and catastrophes on the certain territory with a help of the above mentioned methodology.