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WATER RESOURCES AND THE REGIME OF WATER BODIES

Floods: Genesis, Socioeconomic and Environmental Impacts

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Abstract—The concept of "flood" is formulated with regard to socioeconomic and environmental impacts. An ingenious classification of floods according to their genesis is suggested. Socioeconomic impacts of floods are discussed. A classification of floods according to their socioeconomic damage is proposed. Environmental impacts of floods are studied.

INTRODUCTION

The study of domestic and foreign publications shows that the concept of "flood" is variously understood by different authors. The best known standpoints are subdivided into two groups. The first group includes formulations, which support the definition given in the Geographical Encyclopedic Dictionary: "considerable inundation of an area as a result of water level rise in a river, lake, or sea" [9]. The flood is also generally viewed as "a recurrent short-term or seasonal inundation of land areas with water from any sources due to the action of different forces and under the influence of different factors" [18]. A somewhat different interpretation of this concept is outlined in the Hydrological Dictionary [26]: "inundation of an area within the limits of a river valley and populated areas located above the annually inundated floodplain."

The second group includes the definitions where by the flood is meant inundation of lands used by man; this inundation causes damage to population and economic activities of the affected area.

Many researchers in domestic publications adhere to the definition given in [21] "…inundation of an area adjacent to a river or lake, which causes material loss, adversely affects human health, or results in people death. Inundation of an area, which does not cause serious damage, is associated with water level rise in a river or lake."

The authors of this work support the socioeconomic definition [21] supplemented with environmental aspects and their own interpretation. In the authors' opinion, flood is temporary inundation of an area developed by man for different economic purposes; this inundation results in adverse effects of socioeconomic and environmental nature; the adverse effects cause material and nonmaterial losses as well as inundation of other areas and disturbance of long-term environmental equilibrium, changes in the habitat of fauna and flora and, hence, losses of species or their mutation.

Socioeconomic and environmental impacts of floods are discussed in the work independently of one another. The reason is in the character and reliability of information available for the authors. As for the socioeconomic impacts, there is enough reliable information on this problem and it is possible to estimate direct losses, while it is more difficult to obtain reliable information on environmental impacts and losses. In addition to this, different procedures of assessing the impacts and particularly losses make it possible to consider socioeconomic and environmental impacts separately at this stage of studies.

Floods occur in many areas of the world. They rank first among other natural disasters in their adverse effects. Areas subjected to floods are equivalent to the total area of all the countries of Western Europe, whose population numbers about one billion [2].

The results of processing and analysis of data on river floods over the period of 1998–2003 [28] obtained by the authors showed that the total of 1119 floods were recorded in all the continents of the world over that period of time. The greatest number of floods occurred in Asia and accounted for 40 to 50% of the total number of floods in each year. Generally, the maximum number of floods occurred in June–August and amounted to 34%, the minimum number of floods occurred in February–April and amounted to 20%. The duration of 70% of floods was from one to seven days, 14% of floods lasted up to 14 days, and 16% of floods lasted for more than two weeks, including 7% of floods more than one month in duration. Over 90% of river floods that occurred in the world was caused by rains and their combination with other factors. As regards socioeconomic losses, the tentative assessment for the period of 1998–2003 showed the death of 53 thousand persons in the world. 150 million persons were temporarily evacuated from their permanent residential areas. The total damage caused by floods exceeded $135 billion.

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CLASSIFICATION OF FLOODS ACCORDING TO THEIR GENESIS

As stated in the literature, floods in the majority of areas of the world are caused by rains of different duration and intensity as a result of cyclones. Floods in the rivers of the Northern Hemisphere are caused by intense snow melt, ice jams and ice gorges. Piedmont areas and high mountainous valleys are subject to floods caused by outbursts of glacial and rock-dammed lakes and the formation of mudflows. Tide surge floods are observed in maritime areas under the condition of heavy winds; subwater earthquakes and volcanic eruptions result here in floods caused by high waves, i.e., tsunami [1].

Unfortunately, human activities aggravated the adverse effects of natural floods and provoked the floods, which had never been observed in nature.

The growth of economic development in different areas was accompanied by the increasing impact of anthropogenic factors on the nature of floods and level rise in water bodies. Among these factors, mention should first be made of the following: deforestation, bog drainage, and irrational agricultural practice (heavy compaction of soil cover, longitudinal plowing of slopes, nonobservance of irrigation requirements, etc.). The development of housing system and extension of water impervious pavements result in an increase of mean water discharges during flood periods in urban areas.

The development of flood-plains, which are in fact natural flow regulators, is associated with anthropogenic activities causing inundations (construction of roads, bridges, levees, etc.). Some causes of inundations are related to improper (or unqualified) implementation of flood control measures and irrational operation of reservoirs (breaches or destruction of dams and levees, emergency water level drawdown in reservoirs, etc.). Close attention should be given to floods in upstream and downstream areas of reservoirs caused by irresponsible actions of local administrations; they authorize the building up of land areas, the inundation of which has been stipulated by project designs of waterworks in the years of low flood probability. In addition to this, inundations sometimes occur as a result of unauthorized building up of these land areas by inhabitants of coastal areas [1].

The diversity of natural and anthropogenic factors, which cause floods, necessitates the classification of anthropogenic factors according to the characteristics of the essence of this phenomenon [3].

The comparative analysis of domestic and foreign publications shows that there are different approaches to the classification of floods. In most our works, floods are grouped with regard to the causes of their origination [10, 16, 17, 20, 21, 23, 24]. The number of outlined causes and types of floods corresponding to them differs from author to author depending on the duration, time of origination or frequency of phenomena, as well as on the conditions and place of flood formation.

The most interesting classification of floods developed in our country over the past years is represented in the work [18], where it is proposed to single out 18 natural and six anthropogenic types of floods with regard to their genesis, duration, the frequency of occurrence, and the place of formation.

It should be noted that the emphasis is placed on floods of natural type in the classifications under study and insignificant attention is paid to floods of anthropogenic type. However, anthropogenic causes may not only result in the origination of floods of anthropogenic (human-induced) types but they substantially affect the floods of natural type aggravating their damaging power.

As mentioned in [11], the comprehensive natural and scientific classification of elemental natural phenomena, to which floods are referred, should be genetic and based on the origin, causality, and profound inner essence of the phenomena under study. The author emphasizes the fact that the genetic classification of elemental natural phenomena should take into account not only extremal manifestations of natural processes capable of causing tangible "one-time" effect in the form of numerous victims and material losses, it should also take into account continuous, relatively slow but potentially dangerous processes, which finally result in adverse socioeconomic and environmental effects.

Flood is a challenging (complex) phenomenon. As far as complex phenomena are concerned, it is often difficult to reveal the main causes of their origination. Therefore, while making the genetic classification of floods, the authors tried to single out:

Natural processes, which represent an original cause of floods and initiate a sort of chain reaction in the environment involving interrelated components of the nature. In this case, adverse effects may be related to secondary causes (or processes). For example, devastating floods in piedmont and mountainous area are often caused by heavy atmospheric precipitation, which leads to the formation of mudflows and landslides. The landslides may result in the formation of temporary landslide dams. Thus, precipitation is an original cause, while landslide is a secondary cause;

Anthropogenic processes, which influence the character of formation and development of floods along with natural processes. For example, the maximum runoff of different natural genesis often damages or destroys protection dikes and dams and then the flood develops according to quite another laws; its devastating power increases causing greater material losses to population and economy;

Anthropogenic processes resulting in origination of floods unusual for the nature, i.e. floods caused by the insufficient discharge capacity of municipal storm sewage systems or their clogging, when storm water accumulates on the impervious surface and leads to inundation of urban areas. When revealing the anthropogenic causes of floods, it is necessary to take into consideration the following: the construction of reservoirs, which accumulate large volumes of water, is associated with a potential risk of inundation of areas in the upper and lower pools of reservoir dams. Nevertheless, inundations are caused, in such cases, not by reservoirs proper but the violation of the mode of reservoir operation and by failures in hydraulic structures.

Taking into consideration the above classifications of floods and the work [18], the authors have offered an ingenious classification of floods according to their genesis (Schemes 1 and 2). The idea of this classification was proposed by A.B. Avakyan, who worked hard at the flood problem over the last years of his life.

The classification of floods proposed by the authors is based on the subdivision of floods into two groups: floods in rivers and lakes and floods on coastal areas of seas and oceans. Unlike the findings mentioned in [18], where floods are subdivided into three groups according to the place of their formation (river floods, floods on sea coasts, and floods on coasts of inland seas and lakes), the authors were guided by the fundamental difference between "river" floods and "maritime" floods. They pioneered in proposing the subdivision of each group of floods into three genetic subgroups: natural, natural anthropogenic, and anthropogenic floods.

The proposed classification is initial, and in future, it may be supplemented and specified. However, such approach may essentially influence further studies of floods and their impacts as well as the development of more efficient system of flood control measures.

CLASSIFICATION OF FLOODS ACCORDING TO SOCIOECONOMIC DAMAGE

When studying any elemental natural phenomenon, it is important to know the characteristics of its essence, on the one hand, and the nature and degree of socioeconomic damage caused by the phenomenon, on the other hand [11].

As mentioned currently in domestic and foreign literature, the number of disastrous floods and related losses tends to increase with the growth of population and the development of areas subject to flood risk, particular case studies being cited. However, researchers have not come to an adequate single criterion (or criteria close to each other) to qualify a natural phenomenon having disastrous impacts. For example, one of the Swiss insurance companies believes that one of the two requirements should be met in assessing a disastrous event: no less than 20 casualties or material loss estimated at no less than \$16.2 million [13]. An insurance company of Munich holds that a flood may be considered as a disastrous flood, when there are thousands of casualties, hundreds or thousands of victims, or considerable economic losses are caused [27]. According to another approach [29], a disaster should imply no less than 100 casualties, no less than 100 wounded, or no less than \$1 million of estimated damage. The following criteria are mentioned in the UNEP report on the environmental condition [30]: no less than 10 casualties or the damage exceeding \$1 million.

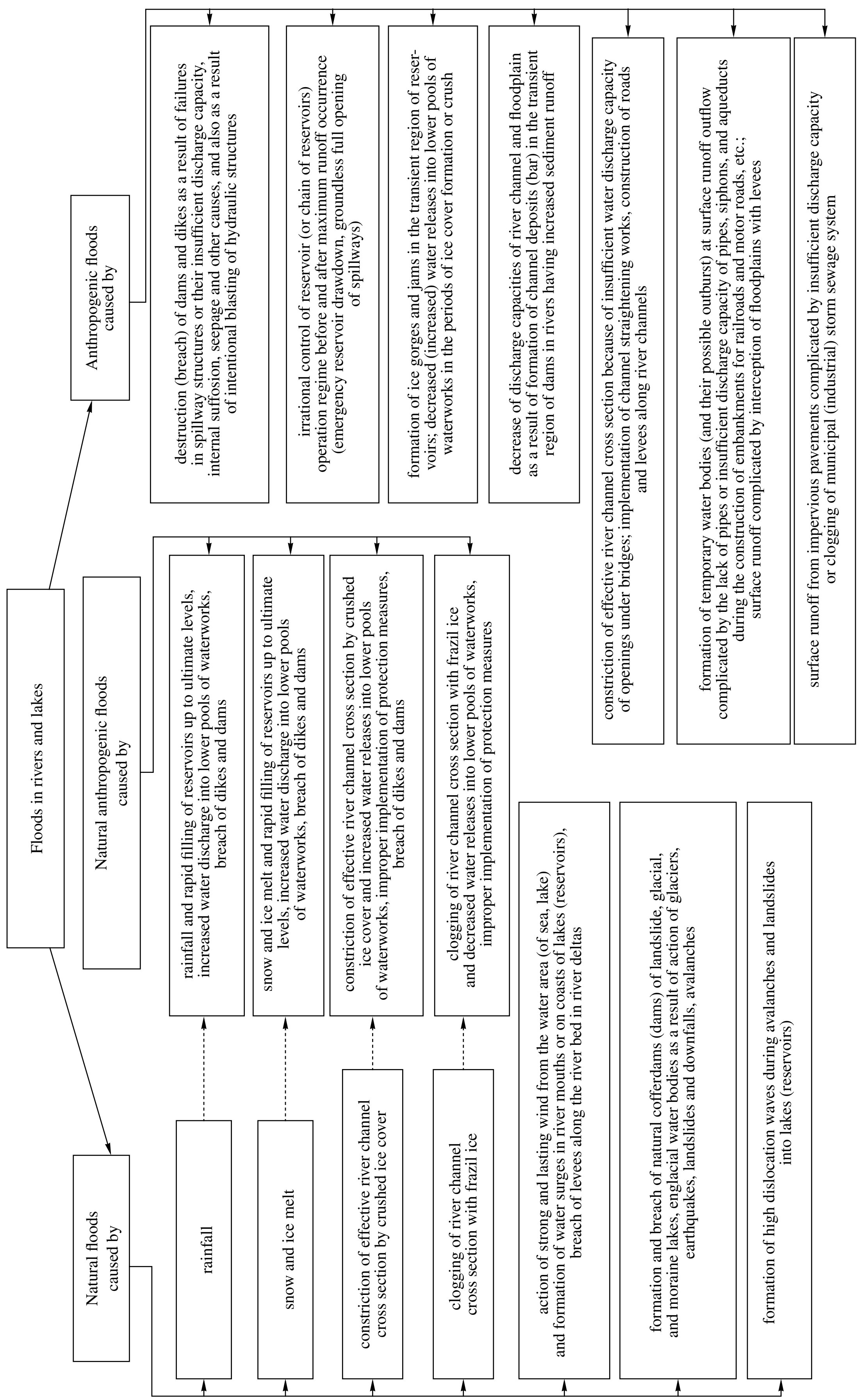
The following classification of emergency situations is available in Russia and used by the Ministry for Emergency Situations: local, territorial, regional, federal, and transboundary emergency situations [12]. Emergency situations are classified depending on: the number of victims; the number of persons, whose living conditions are disturbed; the amount of material loss; the boundary of the zone of propagation of affecting factors.

Federal emergency situations include situations characterized by the following: more than 500 victims, disturbed living conditions of more than 1000 persons, material losses exceeding 5 million minimum amounts of payment for work at the day of emergency situation initiation, and if the zone of emergency situation is beyond the boundaries of two member states of the Russian Federation. The transboundary emergency implies the situation, when affecting factors are observed beyond the boundaries of the Russian Federation, or when the emergency situation occurs abroad and affects the Russian Federation territory.

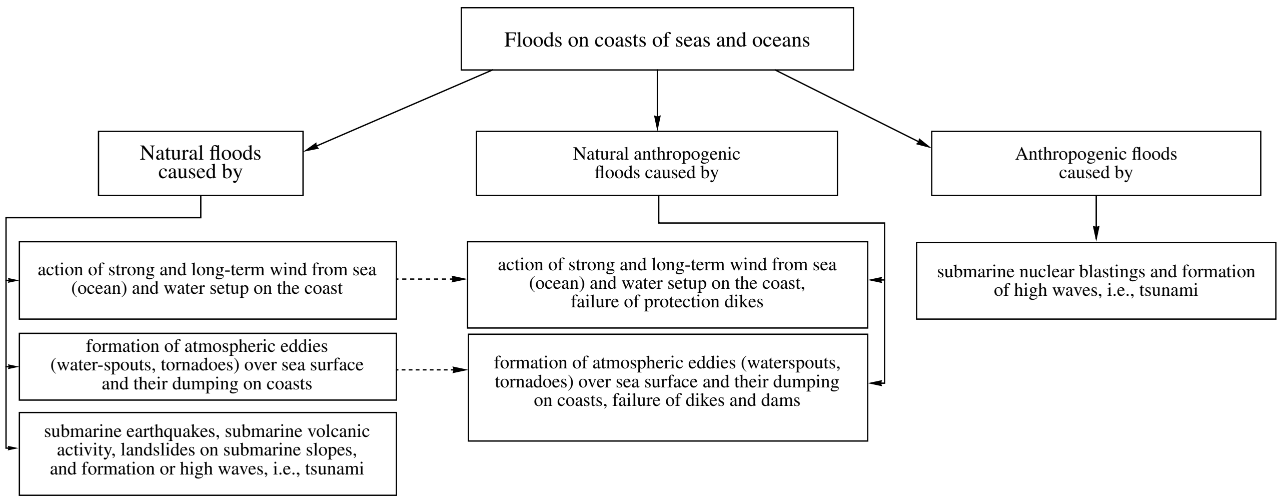
There are no special works devoted to the classification of floods according to the total damage in our and foreign publications; however, some researchers propose their own ideas concerning the possible flood classification [4, 6, 10, 17, 21, 24]. Most authors subdivide floods into four categories to give them qualitative (rather than quantitative) characteristics of the degree of area inundation, disturbance of normal living conditions, and damage. For example, according to [21], the first class (moderate floods) is characterized by inconsiderable material loss, the second class (high floods) features considerable material loss, the third class (extraordinary floods) features very large material loss, and the fourth class (disastrous floods) is characterized by the fact that the damage is caused to several large river basins. Such classification enables each researcher to assign any flood arbitrarily to one or other class of floods. The substantiation of the fourth class is sometimes unjust, because such kind of floods may occur in one river basin (for example in the basins of the rivers of Mississippi, Huang He, Yangtze, Lena, etc.).

The efforts [24] to relate the flood classes to their frequency within a certain number of years are highly questionable, because the progress in civilization and the development of land areas subject to floods may probably lead to more frequent flood occurrence. The reference of the classification to the flood duration, which undoubtedly influences the scale of socioeconomic damage, in the authors' opinion, also cannot be used as a basis for assigning floods to one or other class.

It should be noted that by socioeconomic impacts the following is understood:



Scheme 1. Classification of floods in rivers and lakes according to genesis.



Scheme 2. Classification of floods on coasts of seas and oceans according to genesis.

Death of people; physical injuries and emotional shocks of flood victims; temporary evacuation of people into safe areas; living of some people in houses devoid of water, gas, power supply, and telephone communication during several days and sometimes months;

Inundation, groundwater rise and destruction of dwelling houses, industrial buildings, and different objects of infrastructure (schools, hospitals, shops, warehouses, etc.), railroads and motor roads (particularly, bridges), power transmission and communication lines, water mains, oil and gas pipelines, etc. Inundation and destruction of most of the above-mentioned objects result in the disturbance of living conditions not only in the inundated areas but also in other regions economically and in any other ways connected with inundated areas;

Inundation and loss of agricultural land areas, loss of crop yields and animals.

Socioeconomic impacts of floods depend on the area of inundated lands; population density in this region; the number, composition, kind of structures, construction materials of buildings and structures; the height of dangerous water levels; the duration of inundation; season and even days (for example, before harvesting or after it); the degree of population protection, which is closely connected with the economic development level and the national characteristics of a country (for example, USA, Great Britain and India, Bangladesh).

In the authors' opinion, the most important information, which must be available for classification of floods (particularly in the period of their occurrence) according to socioeconomic damage, is as follows: the number of casualties and temporarily evacuated persons, the total estimation of all types of losses in monetary terms, and the area of inundated lands.

The flood damage estimated in different periods (soon after the flood and several years later) varies noticeably. As a rule, the first estimation, which is usually taken into account, is much lower than the actual damage, because it does not include the consequences of emotional shocks and diseases of population of inundated areas, possible damages of buildings and objects of infrastructure, which can be revealed within many years after the event.

It is extremely difficult to classify socioeconomic impacts of floods for a number of reasons. There are no specialized agencies to keep records of these impacts virtually in all countries of the world. Therefore, even the estimation of the number of casualties is rough. The following statements are often met: several tens (hundreds, thousands) of casualties, several hundreds (thousands, tens of thousands) of persons were temporarily evacuated. The inundation area is also estimated roughly or not mentioned at all. The estimation of damage in monetary terms is particularly unreliable, because only the direct damage is estimated with a certain degree of accuracy. The indirect damage, whose value may sometimes exceed the direct damage value, is not taken into account.

Because of the mentioned problems, most of researchers were reluctant in touching upon these themes. In addition to this, the development of flood classification regarding the scale of socioeconomic damage was hampered by the lack of necessary actual information. When this information was available for the authors [19, 28], it became possible to work out (in collaboration with A.B. Avakyan [2]) such classification.

The authors suggest that floods should be subdivided into five classes (table): class 1 is related to moderate floods, class 2 is related to median floods, class 3 is related to high floods, class 4 is related to disastrous floods, and class 5 is related to historical floods (as applied to those disastrous floods, which have caused extremely severe damages and remain in the people's

Classification of floods according to socioeconomic impacts

Class	Number of victims, person	Number of temporarily evacuated persons, thousand persons	Inundated area, thousand ha	Damage, $million
1	0	<1	<10	<1
2	1–10	1–10	10–1000	1–10
3	1–100	11–50	1000–10000	11–100
4	101–2000	51–1000	10001–50000	101–10000
5	>2000	>1000	>50000	>10000

memory for many centuries). The data used for substantiation of the classification of floods were obtained as a result of comparison of the data on more than 900 floods.

The corresponding class is assigned to a flood under the following conditions:

If the figures of two (or more) out of four substantiations enter one class, this class is assigned to the flood (for example, if 1–2–2–3, then class 2 is assigned);

If two substantiations fall into one class and two other substantiations fall into another class or if substantiations are distributed among different classes, special attention should be given to the order of individual figures concerning the flood and range of variations. The corresponding class is assigned to floods depending on the proximity of initial data to the lower or upper boundary of values of neighboring ranges (for example, if 2–2–3–3 or 1–2–3–4, then either class 2 or class 3 is assigned);

If the data for substantiations are insufficient (for example, three out of four) and they are in different classes, the intermediate class is assigned to floods (for example, if 1–2–3, then class 2 is assigned);

If there are figures only for one of the four substantiations, its value decreases by an order of magnitude (for example, if 2, then class 1 is assigned).

Based on the developed classification, the authors systematized and analyzed floods that occurred in the world and in Russia during 1998–2002 (823 and 122 floods, respectively).

The authors' studies revealed that the majority of floods known from the records of the Dartmouth Observatory [28] fall within class 2, i.e., median floods (Fig. 1). The reason is that the staff members of the observatory, who have provided the data, collect the information on floods using a number of information sources, including mass media news and governmental press reports. It is the worldwide practice that the greatest attention is given to floods causing significant socioeconomic damages; the events accompanied by insignificant damages and victims are often overlooked.

The results of systematization of data on floods occurred in Russia are somewhat different. The data were taken from annual reports on emergency situations published by the Ministry for Emergency Situations irrespective of the damage caused [19]. Most of the floods were assigned to class 1, i.e., moderate floods, rather than to class 2 (figure).

When studying the distribution of disastrous floods in the world by years with regard to the classification of floods according to socioeconomic damages, the authors came to the conclusion that 24 disastrous floods occurred in 1998, 11 disastrous floods occurred in 1999, 9 disastrous floods occurred in 2000, 11 disastrous floods occurred in 2001, and 11 disastrous floods occurred in 2002. One flood of this class occurred in Russia in 1998, such floods were not recorded in Russia in 1999 and 2000, one disastrous flood occurred in 2001, and one disastrous flood occurred in 2002.

As estimated by the authors, the maximum number of disastrous floods (24) occurred in the world in 1998; for example, a series of disastrous summer floods was recorded in China in that year. The figures concerning other years virtually remained unchanged (9–11 disastrous floods a year), but their values were high enough.

Three disastrous floods occurred in Russia over the period under study: disastrous floods caused by ice gorges occurred in the Lena River, Sakha Republic (Yakutia), in 1998 and 2001; in 2002, a rainfall flood occurred in the Southern Federal Region. A number of other floods, which occurred in Russia and were widely covered in mass media followed by a considerable public response, were assigned to the class of high floods with regard to their socioeconomic impacts.

It was worth mentioning that none of the floods under study, which occurred in the world and in Russia over the period of 1998–2002, was assigned to class 5. This supports the conclusion that such events are extremely infrequent.

No doubt, that the inundation having extremely grave socioeconomic impacts, which occurred in South East Asia on December 26, 2004 as a result of tsunami, should be assigned to the class of historical floods. The information on this event arrived, when the article had been already written. The tsunami was caused by a submarine earthquake of the magnitude of 8.9 according to the Richter's scale; the earthquake occurred in the area of the island of Sumatra. The inundation affected 12 countries, including Indonesia, Sri Lanka, India, and Thailand. About 300 000 casualties, thousands of people disappeared, some millions of persons became victims.

The preliminary estimation of material loss exceeded $20 billion.

ENVIRONMENTAL IMPACTS OF FLOODS

Along with socioeconomic impact, environmental impacts of floods are of special interest, because, as mentioned above, floods essentially affect not only the social life but also the environment.

The study of domestic and foreign literature, as well as the collection of additional information about actual events permitted the authors to generalize and represent certain information about the environmental impacts of floods. It should be noted that little attention is given to this problem in our publications.

By and large, the environmental impacts of floods should involve changes in the chemical composition of water and dramatic deterioration of its quality, the influence of floods on soils, fluviomorphological deformations, disturbance of vegetation cover and fauna.

The river water turbidity reaches its maximum value during flood periods, its drastic increase being observed in the period of water level rise. The graphs of water discharge vs. mean turbidity and suspended sediment flow rate have a loop-shaped form, which is also typical of normal conditions [15].

To understand the processes of water quality formation during flood periods, it is necessary to know the origin of suspension, which is formed from products of water erosion of soil cover in the catchment area (soil loss products) and channel erosion (washout products). Great quantities of soil loss products from the catchment surface enter the river channel during the water level rise. Because the river flow velocity and the degree of water admission into the channel are insignificant in this period, coarse particles of water erosion products coming into the river precipitate, while fine particles are transported in suspension. As the water discharge increases, the competence of stream grows and a certain amount of coarse particles of bedload starts moving in suspension. During the water level drop, the transport of both coarse and fine particles drastically decreases. The greater part of the suspended matter runoff consists of products of soil cover of a catchment basin. This fact is proved by field data on particle sizes of suspended sediments and the surface layer of river bedload. The particle size of suspended sediments during the river water level rise is significantly less than the particle size of bedload. The data shows that 80–97% of the content of suspended sediments during high flow period, moderate and median floods is represented with particles less than 0.05 mm in size, while at the same time the content of particles of the same size in bedload does not exceed 4% [15]. Such correlation of particles is also observed in bedload during low-flow periods. However, high and disastrous floods carry a considerable quantity of products of river channel washout. When catchment basins are inhabited and have agrolandscapes, the soil cover is polluted and pollutants enter the river together with solid particles.

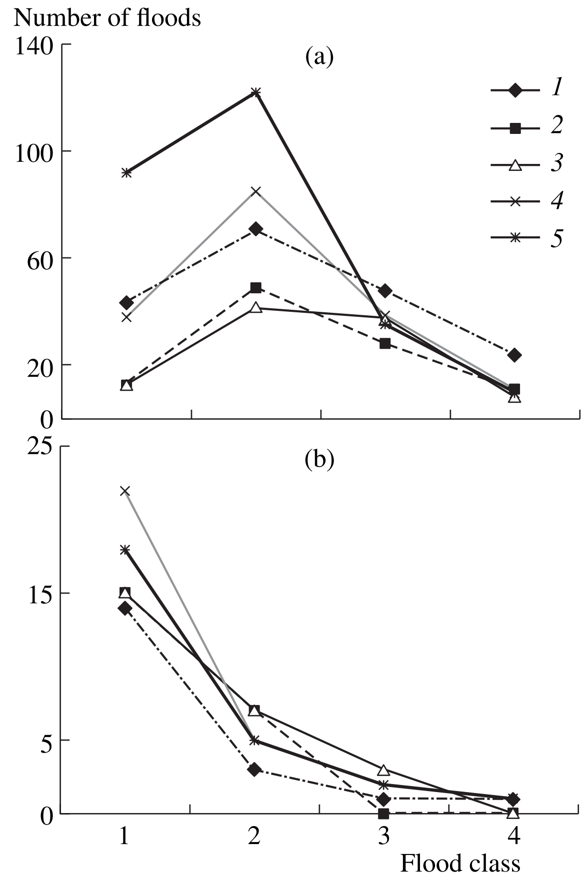


Fig. 1. Distribution of floods (a) in the world based on data [28] and (b) in Russia based on data [19] over the period of 1998–2002 in compliance with classification of socioeconomic damage; *1–5*, respectively.

Floods are accompanied with a dramatic reduction of total salinity and the content of major ions of Ca, Mg, Na, HCO_3, and Cl. The losses of *K*, organic substances, and biogenes from catchment basins noticeably increase.

The relationship between the content of individual ions and water discharges has a complicated, often loop-shaped form close to a triangle [22]. Relationships between water discharges and concentrations of heavy metals, pesticides, and other organic substances are much more complicated. During floods, the river water quality is naturally impaired: concentrations of heavy metals, biogenic elements, and pesticides dramatically grow. The greater the human-induced impact on catchment areas, the greater this deterioration.

Emergency spills of toxic chemicals, oil, and oil products in case of failure of pipelines and tanks are particularly dangerous during floods [7]. The amount of substances discharged into water bodies and streams sometimes reaches many hundreds of tons. This results in the formation of polluted water streams characterized by the extremely unsteady hydrochemical regime, which can hardly be controlled.

Floods have an essential effect on soils, their properties and fertility. Environmental impacts of floods have positive and adverse effects and are well pronounced in river floodplain areas.

Moderate floods, which are observed during spring snow melt in plains, have a positive effect on soils and adjacent components of floodplain landscapes under the condition of optimal flood duration, low velocities of high water flow and a definite thickness of alluvial fan in the floodplain and first terraces. The positive effects of such floods include: leveling of floodplain relief, enrichment of soils with fertile dust-like silty particles and organic residues, removal of readily soluble salts, saturation of soils with fresh water, loss of weeds and pests.

The fertility of floodplain soils increases, provided the duration of flood water stand does not exceed 20–25 days and the thickness of deposits varies from 0.1 to 0.7 cm. As a rule, alluvial deposits of insignificant thickness are characterized by an increased content of fine fractions, favorable mineralogical and chemical features, and considerable reserves of biogenic elements [8].

The maximum thickness of deposits is observed along the river bed in narrow floodplains. Thick alluvial deposits (more than 0.7 cm) are often composed of sand particles poor in nutrients. Floodplain soils, whose humus horizon may be buried under a thick sand layer, lose much of its fertility.

Disastrous floods affect floodplain landscapes. Such floods are usually accompanied by water erosion and loss of a portion of fertile humus layer of soils. The problem of estimation of flood damage and related soil erosion and loss of soil fertility in river valleys is still insufficiently studied.

Depending on the degree of soil erosion, humus reserves decrease from 10 to 75–100% in a 1-m-thick soil layer as compared with similar noneroded soils. The absolute values of humus reserve reduction vary within wide limits from 54–94 t/ha to 149–277 t/ha in soils of different genesis. Noticeable reduction in fertility of eroded soils and in reserves of mobile forms of N, P, and K is recorded. Losses of N vary from 2.7 to 14.0 t/ha, losses of P vary from 1.3 to 1608.2 t/ha, and losses of K vary from 59.0 to 6353.3 kg/ha [14].

Inundations of very long duration exceeding 30 days may cause the development of gleying and bogging processes, which affect the level of soil fertility [8].

Intense fluviomorphological deformations occur during floods; they may be both horizontal, when the river channel location is changed in the plan, and vertical, when the channel elevations are changed. Bank undermining results in damage of buildings and structures, towers of power transmission lines, and bridges; it may cause landslides and downfall as well as losses of agricultural lands. On the other hand, bank undermining may cause silting and shoaling of water areas of ports and water intake structures. Such deformations regular in their impact are most pronounced in wide floodplains, when the floodplain is two–three times wider than the river channel.

There is a classification of Russian rivers according to the risk of fluviomorphological processes. The classification is based on the objective data (particle sizes of alluvium, river slope, and floodplain structure) and permits the assessment of river channel resistance to river floods [5].

In the course of evolution, the natural selection of plants adapted to short-term floods in river floodplains occurs. It is common knowledge that flooded meadows in river valleys feature the maximum productivity. Properly cultivated fodder crop lands are able to yield 6 t/ha at the mean productivity of the rest floodplain lands approximating 2 t/ha [25].

The development of vegetation on flooded lands greatly depends on the terms of inundation with flood water, depth of inundation, groundwater level, temperature of flood water and soils, thickness and composition of alluvial deposits, and on the variety characteristics of plants.

It is found that inundation of a floodplain over a period of 10–20 days does not affect the development of meadow vegetation; after the recession of flood, a rapid growth of vegetation is observed due to deep soil moistening. The inundation lasting for more than 50 days may result in wilt of plants and often in their loss [25].

Due consideration of the degree of plant tolerance makes it possible to properly choose the varieties of plants or their mixture for sowing in floodplains. Gramineous plants are characterized by a higher tolerance to floods as compared to legumes. Sweetclover and alfalfa can grow only under the condition of short and median duration of inundation, while brome grass, canary grass, and slough grass withstand well during longer inundation periods.

Under the condition of long-term moistening, when the inundation period lasts up to 15–20 days, the maximum yields and good fodder quality of grass mixtures are provided by the following varieties: awnless brome grass, red clover, meadow peavine, bird vetch, white clover, meadow foxtail, couch grass, and timothy grass [8].

Any special studies of the impact of floods on the fauna have not been undertaken. It may be reasonably concluded that floods are likely favorable for individual species of insects and amphibia, and water fowl and animals. However, flood is a real disaster for the majority of animals.

Disastrous floods often cause the loss of wild and agricultural animals. After the recession of floods, wild animals are forced to migrate into other areas because of the lack of food, while owners of agricultural animals have to use purchased feed for their animals because of the loss of natural fodder land areas. The deterioration of water quality in water bodies and streams has an adverse effect on the condition of populations of fishes, birds, and animals. The pollution of natural water with toxic chemicals, oil, and oil products is particularly dangerous for the fauna and may lead to its loss.

CONCLUSIONS

The greater number of floods occurs in rivers as a result of rainfall within the area of water catchment basins; the duration of inundations does not exceed seven days in 70% of events.

Human activities are the main cause of a series of human-induced floods and they often aggravate the harmful impacts of floods of natural origin.

The proposed classification of floods according to their genesis opens up possibilities for detailed study of relationships between the main characteristics of floods and their causes.

Based on the data on more than 900 floods that occurred in the world during 1998–2002, a classification of these floods according to socioeconomic damages has been prepared. As shown, the greater part of floods observed in Russia in those years is assigned to class 1, i.e. moderate floods without victims, the number of temporary evacuated persons being less than 1000, the estimated damage not exceeding $1 million.

The impact of floods on natural processes is ambiguous. Floods moderate in their intensity and duration often improve soil properties and fertility. They increase the productivity of flooded meadows, and favor the conditions of habitats of individual species of water fowl and animals. Disastrous floods affect floodplain landscapes, cause the loss of agricultural lands, loss of animals and plants, and deterioration of water quality.

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