Vulnerability as a Key Factor of Escalation from Disaster to Catastrophe: Megacities versus Small Towns

Boris Porfiriev,
Risk and Crisis Research Center at the Institute of Economy, Russian Academy of Sciences,
Novocheriomushkinskaia, 46 117418 Moscow, Russia, b_porfiriev@hotmail.com

Abstract
While natural and technological risks to megacities worldwide have been recurrently emphasized by practitioners and scholars vulnerability of the small towns has been much less a focus of the social science studies. A notable exception is provided by respective investigations of the developing nations with the small towns in the industrialized and transitional economies being at the peripheral interest of researchers. It is argued that whatever high is the megacities exposure to and impact by disaster agents, metropolitan areas have much greater disaster resilience and thus reduces vulnerability to and cushions severity of disaster impact. Meanwhile, small towns lack the political influence and economic power of megacities that determine resilience capacity, which in turn could decisively reduce the risk of disaster's escalation to catastrophe. In addition, yielding to megacities in the absolute number of people at risk often far higher proportion of the small towns' population and economic assets are vulnerable to disaster impact. Eventually, megacities experience mostly debilitating (although undoubtedly major) effect produced on them by disaster agents, while that produced on the small towns is often extremely disastrous and even turns into a real catastrophe with particular communities totally devastated. This reveals much more complicated picture than usually portrayed and corroborates the smaller communities' increased risk (as contrasted to big cities) to experience devastating impact of a disaster's escalation to catastrophe

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Introduction

The vulnerability of megacities both to natural and technological hazards has been particularly stressed by practitioners and scholars worldwide in recent decades[1]. It is argued and proved that metropolitan centers (that are the primary focus of this workshop in Stockholm) with their large and rapidly growing populations and concentration of wealth, especially those located within the coastline or seismic zones are most exposed and worst hit by disasters. This paper attempts to consider this issue from different, namely comparative perspective, by contrasting vulnerability of the megacities to that of the small towns using both impact and resilience characteristics as key variables.[2] Within this context it is argued that increased vulnerability of the small communities as contrasted to big cities with other factors being equal provides for a major driving force of a disaster's escalation to catastrophe.

To verify and substantiate this non-trivial key tenet we start first with consideration of the verbal model of escalation from disaster to catastrophe with a

[1] See, for instance: *Megacities: Reducing Vulnerability to Disasters*. Institution of Civil Engineers, Trowbridge: Thomas Telford, 1995; Mitchell, J.K. *Crucibles of Hazard: Mega-cities and Disasters in Transition*. Tokyo: United Nations University Press, 1999.Sylves, R. and Waugh, Jr. *Cities and Disaster*. Springfield, Charles c. Thomas, 1990.
[2] In doing so we build upon and expand the ideas provided in: Cross, J. Megacities and Small Towns: Different Perspectives on Hazard Vulnerability. *Environmental Hazards*, 2001, Vol. 3, No 2, p. 63-80.

brief description of its driving forces and indicators. This is followed by formal interpretation and decomposition of vulnerability as the major factor of a disaster's escalation to catastrophe. In the last section the revealed components of a community's vulnerability to disaster agents in megacities are contrasted to those in small towns using some statistics and more living facts of the Russian experience of the late 20th – early 21st century.

Escalation from Disaster to Catastrophe: A Development Model

Within a set of categories used in social science to study the gamut of the non-routine phenomena and processes (non-conflict in particular) crisis and disaster are perhaps the most widely used. This should be both a reflection of the degree of ubiquity of respective unscheduled events and traditions existing in research schools and literature. This understanding does not blur but necessarily imply consideration of these and other relevant notions as interpretations of interweaved occasions and events, which could make up development stages within a trajectory of a process, which disturb community's social continuity and holisticity (Fig. 1), and/or involve qualitatively different states of a community's social fabric debilitation and rupture (or social entropy and disarray in terms of Prigogine's theory of chaos)[3] (Table 1).

Table 1

Crisis type	Qualitative (verbal) description
Acute crisis (emergency)	Involves temporary break of normal social routines, relatively limited number of affected people (casualties) and economic damage in a given social system, which could be almost fully recovered (compensated) within a comparatively short time
Chronic and/or persistent crisis (disaster)	Involves long-term and overall break and substantial rupture of the social routines (communications) and structures within a given social system including human losses, health and / or environmental deterioration, considerable distress load on the affected community, huge material damage which may be restored, rehabilitated and compensated to a significant degree within a comparatively long-term perspective only
Devastating and Ruinous (catastrophe)	Involves long-term, complete break and rupture of the social communications and structures within a given social system including numerous human losses and casualties, mass health deterioration and morbidity, huge distress load on the affected social community and stress over neighboring and more distant communities, enormous and practically irreversible social, environmental and material damage that may be partially covered somewhere in a distant future only

[3] Prigogine, I. and Stengers, I. *Order out of Chaos: Man's New Dialogue with Nature*. London, Heinemann, 1984.

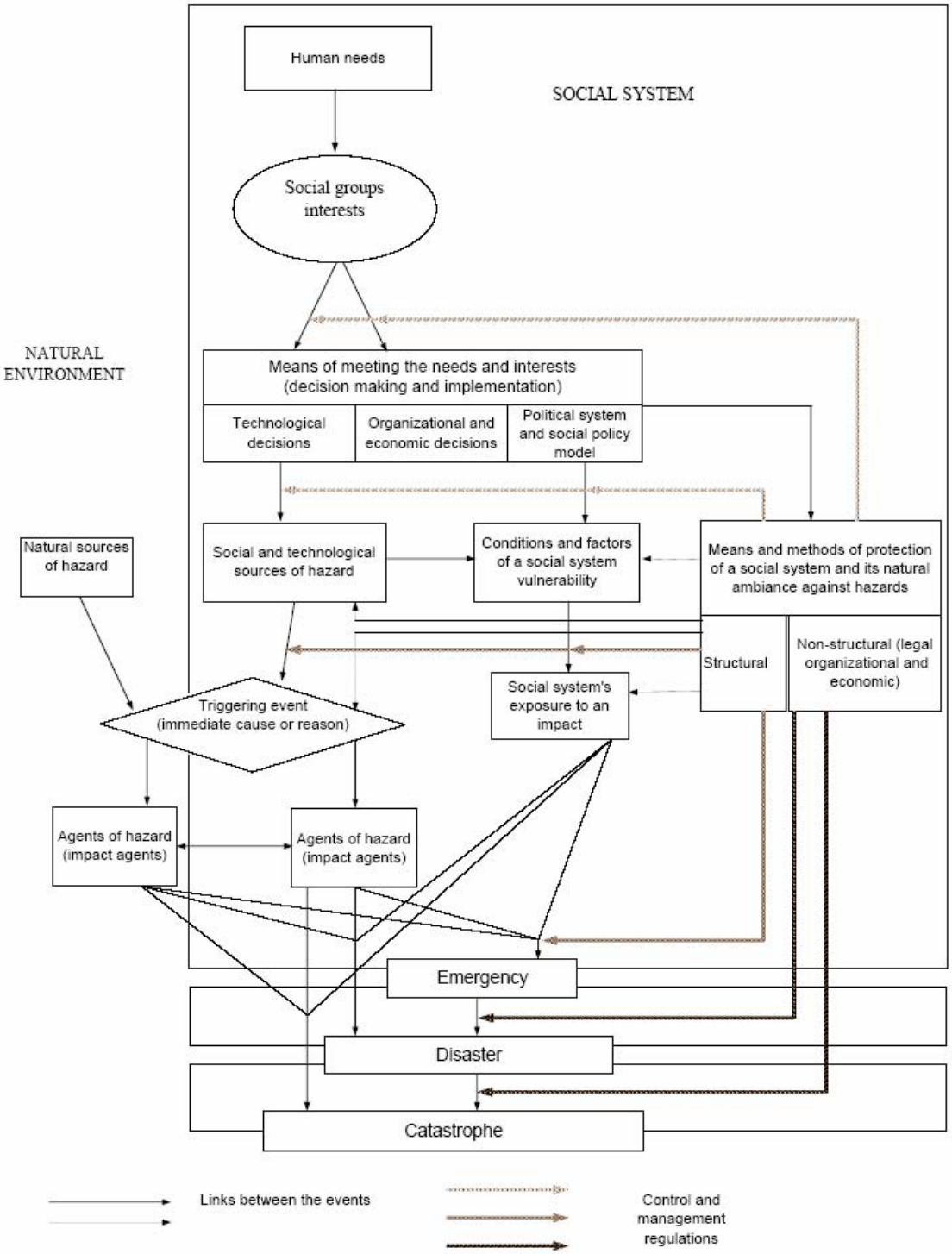

Fig. 1 Crisis Development: Factors and Path Stages

Source: Porfiriev, B. *Disaster Policy and Emergency Management in Russia* . N.Y. , Nova Science Publishers, 1998, p. 38 (edited)

Within such conceptual approach one could believe crisis the most appropriate generic notion to characterize this process. This builds upon the modern social science conceptualization of a crisis, which interprets it a process rather than an event that involves a serious threat to the basic structures or fundamental values and norms of a social system that – under time pressure and highly uncertain circumstances – necessitates making critical decisions.[4] Although time and again we have doubted time pressure being immanent metric of a crisis (and cited the examples of economic, environmental and other kinds of slow-burning crises[5]) here it is important to emphasize that the abovementioned conceptualization of a crisis provides for the generic model of crisis development and interpretation of disaster and catastrophe as the two final stages of this development path (see Fig. 1).

As Fig. 1 shows a catastrophe emerges in two different ways. It may pop off from a hazard agent direct impact on community, which whatever prepared and protected can not withstand the severity of such impact precipitated by non-precedent strong and devastating force of nature or man-made sources. In such a case no escalation from disaster and evolution curve occurs with an emergency immediately turning into a catastrophe. Otherwise, a catastrophe may escalate from a disaster, which in turn could either evolve (extend from an acute to protracted crisis) or flared out (expand and aggravate from minor to major fast-burning crisis) from an emergency.

The latter catastrophic crisis development model that is of particular interest of this presentation paper, involves a set of factors, which precipitate and catalyze (accelerate) a disaster's escalation into a catastrophe. These factors are associated with a specific community's preparedness, response to and recovery from disaster and imply two basic characteristics.

First, the development level and type (kind) of a community exposed to and to be protected against the disaster agent impact. Equally severe disaster impacts on relatively similar protected communities could produce qualitatively different political, social and economic implications, which would require different crisis management policies, in particular in terms of planning. For instance, one could easily to imagine the contrast between the impact of a single or cascade of devastating disasters like hurricanes Katrina, Rita and Wilma put together or earthquake analogous to that in 1906 in San Francisco on a US big city and that on Singapore. In the former extreme situation would force total evacuation of the people to the neighboring regions, which would mean noting more than a major national disaster, while for the latter such occasions would be considered a catastrophe. This leaves alone no less impressive contrast between the impact on the abovemen-

[4] See: Rosenthal, U., Boin, A. and Comfort, L. The Changing World of Crises and Crisis Management. In: Rosenthal, U., Boin, A. and Comfort, L. (Eds.). *Managing Crises: Threats, Dilemmas, Opportunities*. Springfield, Charles C. Thomas, 2001, pp. 5-27.

[5] See, for instance: Porfiriev, B. *Disaster Policy and Emergency Management in Russia*. N.Y. , Nova Science Publishers, 1998, p. 28-36;Porfiriev, B. Managing Crises in the EU: Some Reflections of a Non-EU Scholar. *Contingencies and Crisis Management*, 2005, Vol. 13, No 4, p. 145-152.

tioned cities and those in developing countries, between small remote town and metropolitan area (see below).

Second, mentioned should be comprehensiveness, consistency and timeliness of disaster mitigation, coping and alleviation procedures and measures; and leadership, competence and accountability of management and personnel carrying these out. Failure in one or some of these crisis management elements may facilitate or trigger escalation from disaster to catastrophe. The risk of such a failure is never zero given the heterogeneity of a community to be protected and complexity and uncertainty of disaster mitigation and alleviation to prevent escalation to catastrophe. However, as social theory and policy/management practice show, the type of political regime, social order and organization pattern (at the corporate level), which create the framework and environment of a particular crisis decision support and decision making plays a major role in reducing such risk.

In this connotation worth special consideration is the issue of openness or in a broader sense democratic nature of a given organizational or social system. Multiple evidences reveal applicability of command-and-control approach towards crises management implemented by deploying and using an incident command system. This creates ground for temptation to consider it a universal crisis management tool to be employed here, there and everywhere; which logically means disaster policy, and in a broader sense organizational and societal design, providing appropriate conditions for using this tool.

However, its efficiency to reduce the risk of disaster's escalation to a catastrophe is constrained by the relatively short "hot" stage of crisis response and immediate alleviation. And even at this stage, as experience of using the Army as rescuers during the 1995 Hanshin-Awaji major earthquake disaster in Kobe (Japan) shows, efficiency could not always be considered granted precluding improvisation, particularly important in conditions of uncertainty and complexity fertile for escalation from disaster to a major disaster and eventually to a catastrophe. If disaster preparedness and recovery are considered the total command-and-control model turns to be counterproductive.

Moreover, in times of normalcy when preparation to crises and disasters should be organized orientation on this model in social and economic policy terms would mean more centralized and closed social and/or organizational system, more technocratic and bureaucratic mode of decision making and implementation. Such types of culture, worldview and way of doing things are characterized by superiority of "political expediency" over human values, means and methods over the goal, tactical aims over the strategic mission, symbol over reality. Human conscience, morale, empathy, social responsibility and even the value of human life are considered less or the least important.

As a result, control, manipulation and cover up of information including media are employed, which distort the real picture of a disaster and create favorable conditions of its escalating into a catastrophe. One could immediately recollect radiation disaster in Chernobyl in 1986 that badly affected unwarned communities including big cities and small hamlets in and outside the former Soviet Union; toxic spill in China in 2005 that was covered up for some weeks thus letting the

chemicals contaminate vast areas to the North including those in the Russia Far East.

In the sake of fairness and research purity, however, one should specially note that information distortion and shortage, the major obstacle to efficient management that stems from the abovementioned command-and-control model of disaster policy and institutional rigidity, could also be precipitated by the low level of economic development associated with resource scarcity further aggravated by geographical remoteness of specific area. As contemplation below shows, this is particular important for Russia expanding over 11 time zones, especially for the small towns.

Vulnerability as the Major Factor of a Disaster's Escalation to Catastrophe: A Formal Interpretation and Decomposition

If put together the abovementioned set of factors, which precipitate and catalyze (accelerate) a disaster's escalation into a catastrophe and are associated with a specific community's preparedness, response to and recovery from disaster, could be coined into one systemic category, vulnerability. In a formal way this could be written as

$$V_{c/a} = f\,(S_i, E_{c/a}, R_{c/a}^{-1}) \qquad (1),$$

where $V_{c/n}$ denotes vulnerability of a community or area; S_i, severity or magnitude of hazard impact, $E_{c/n}$ community or area's exposure; and $R_{c/n}$ community or area's resilience to such impact.

The right member of equation (1) could be further decomposed in the following way:

$$E_{c/a} = f\,(N_{c/a}, C_{c/a}) \quad (2),$$

where $N_{c/a}$ symbolizes the number of people in an exposed community or area; and $C_{c/a}$ the tangible values (assets) in an exposed community or area.

$$R_{c/a} = f\,(S_{c/a}, W_{c/a}, E'_{c/a}, A_{c/a}, F_{c/a}, L_{c/a}, M) \qquad (3)$$

where $S_{c/a}$ denotes structural adjustments (construction quality of residential buildings, industrial and protection facilities, e.g. dams, etc.) in a given community or area; $W_{c/a}$ availability and efficiency of hazard warning; $E'_{c/a}$ emergency services' response capabilities (SAR, medical, transportation services, evacuation planning and early evacuation); $A_{c/a}$ public and industrial personnel awareness and preparedness; $F_{c/a}$ availability of funds for response and recovery; $L_{c/a}$ availability and efficiency of logistics and management support for response and recovery in a given community or area; M availability of the local, regional and national media support (publicity and official recognition of a disaster).

A closer look on the variables, which make up components or elements of the communities' vulnerability to disaster agents and eventually determine the de-

gree of such vulnerability, and contrasting those in the megacities to those in small towns reveals a complicated and often controversial picture.

Community's Vulnerability to Disasters: Megacities versus Small Towns

Tables 2-6 below provides comparison between the effects produced by disaster agent on a specific vulnerability component revealed above of a 'typical' megacity and that of a small town. Elsewhere in the tables "<" denotes less, "≤" less or equal to; and ">" more.

Table 2

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small Town
Exposure ($E_{c/a}$)	Floods	Probability of event (P_e) and proportion of a community and facilities experiencing it (%)	<	
	Earthquakes		≤	
	Hurricanes		≤	
	Industrial accident		>	

Table 3

Vulnerability component	Criteria	Indicator	Megacity	Small Town
Severity of impact (S_i,)	Probability of destruction	Frequency/sq km	More often	Less often
	Degree of destruction	Percentage of the total affected area	Small/ medium	Large/ enormous

Table 4

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small Town
Structural adjustments ($S_{c/a}$)	Floods	The number and height of flood levees, dams, number of reinforced and retrofitted structures, redundant safety systems	>	
	Earthquakes		>	
	Hurricanes		>	
	Industrial accident		>	

Table 5

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small Town
Availability and efficiency of hazard warning ($W_{c/a}$)	Floods	Number of river gauge stations, radio and automatic warning systems and their functionality	>	
	Earthquakes		>	
	Hurricanes		>	
	Industrial accident		>	

Table 6

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small Town
Emergency services' response capabilities $(E'_{c/a})$	All types of hazards	Number and equipment of SAR personnel, fire-men, hospitals and medical personnel (both absolute and per number of residents)	>	
Availability of media support $(M_{c/a})$		Visibility and publicity of a disaster event	>	

The data in tables 2 and 3 show that a typical big city as contrasted to small town is more exposed to industrial accidents (exception provided by small and medium towns-factories), less or equal to natural hazards with probability of destruction usually higher. However, whatever high a megacity is exposed to and actually affected by disaster agents it experiences much less risk of huge economic damage, which if occurs covers a minor part of the metropolitan area (see Table 3). This stems from their relatively less vulnerability provided by much higher resilience to disasters, which involves not only more widely used structural adjustment measures, more available and better developed warning systems, and much more efficient urgent response services but also much higher political and media support (Tables 4-6). At the same time, small towns lack the political influence and economic power of megacities small towns lack the political influence and economic power of megacities that determine resilience capacity no less than availability of the funds. In addition, yielding to megacities in the absolute number of people at risk, in small towns often far higher proportion of the living area and population are exposed and affected (see Table 3).

This generic observation is important to and consistent with the Russian realities. Table 7 below reveals that a handful of megacities, which accommodate slightly more than a quarter of the total population, concentrate economic power in terms of capital assets and even more in financial resources.

Table 7

	Percentage of the total population*	Percentage of the total capital assets**	Percentage of the total financial flows**
Rural	27	15	5
Urban	73	85	95
(Megacities***)	(18)	(48)	(85)
Total	100	100	100

* Rounded numbers from official statistical sources

** Author' assessment

*** 12 cities with more than 1 million people each including Moscow (11 million) and St Petersburg (5 million)

Even leaving alone human capital, which is embodied in modern construction and organizational technologies and in those who develop and use them to provide more efficient disaster risk reduction and which is also highly concentrated in megacities this implies more funding for strengthening communities' resilience. In turn this implies less vulnerability and, within the context of the key issue considered in this presentation paper, much less risk of escalation from disaster to catastrophe. Composed into a set of tables provided in the annex to this paper the comparative data, which contrast the impact and implications of specific disasters in the largest city of Moscow and the small towns of Russia, particularly those in the Urals, Siberia and the Far East, corroborate this important finding.

Conclusion

The above comparative analysis of megacities and small communities' vulnerability and risk of escalation from a disaster to catastrophe with Russia taken as a case reveals a much more complicated picture than typically portrayed. This involves the forefront of the megacities debilitated by disaster impact with a more or less significant part of a specific conurbation destroyed by such impact. This blurs or shadows the often completely ruined or totally devastated small towns, villages and hamlets. These hidden evidences of a catastrophe provide an unpretentious background alone for the more visible and thus more symbolic picture of vulnerability of megacities, which resiliency precluded such a tragic outcome escalating from a disaster.

This serves a lesson and calls for a more balanced approach to both practical policy and research in the area disaster risk management and crisis policy. From academic perspective it pinpoints to more focusing on regional studies and comparative explorations of communities' vulnerability and resilience. In policy terms this implies more attention of the federal and regional authorities and media to the small towns and villages in hazard prone areas. More specifically, it means political, financial and organizational assistance to build resistant communities at pre-crisis stage, efficiently rescue people and reduce the damage at trans-crisis stage and recover from disaster after the crisis impact subsides. Meanwhile, the megacities should rely more on intercity, intra- and interregional cooperation with relatively less share of the federal resources involved in disaster management, especially for mitigation. These measures if put together will provide for significant contribution to minimize the risk escalation from a disaster to catastrophe.

(A) Hurricane in Moscow, 1998

A Snapshot of Moscow City

Area (km^2)	900
Population (million people)	8.5
Population density (people/ km^2)	9,444
Share in GDP (%)	~20

Hurricane Profile

Timing	22:00, 20.06.1998
Wind speed	20-30 m/sec
Rainfall	150 mm/day
Hail	5-15 mm hailstones

Impact and Damage

Number of people affected (million)	6.5
Number of killed	9
Number of injured	173
Number of hospitalized	122
Number of houses damaged (roofs and windows)	~ 100
Direct economic losses (US$ million)	~ 3.5

Recovery Data (days)

Rehabilitation of electricity lines and roads	0.12 – 0.15
Repair of the damaged houses	3 – 4
Clearing off the fallen trees	150 – 180

(B) The Earthquake Disaster in Sakhalin, 1995

A Snapshot of Sakhalin Island

Territory (km^2)	76,000
Population	700,000
Population density (people/ km^2)	9,2
Population of Neftegorsk	3,000

Quake Profile

Occurrence time	1:04 a.m. (local time)	28 May 1995
	1:04 p.m. (GMT)	27 May 1995
Magnitude	7.1 – 7.6 (Richter scale)	

Impact and Damage in Neftegorsk

Casualties number		Damaged facilities	
Instantly killed	1,989	Houses*	26
Missing	350	Totally destroyed	17
Injured	375	Severely destroyed	0
		Partially destroyed	9
		Buildings	9

*Impact and Damage to Life-Line Utilities**

Suspension of water supply	All houses in Neftegorsk for 24 hours
Impact on electrical grid lines	200 km
Impact on communications (telephone)	300 km
Impact on oil pipelines	45 km
Impact on gas pipelines	1 km
Suspension of oil and gas terminals	3
Direct economic losses (US$ million)	100
Indirect economic losses (US$ million)	300

* Municipal houses alone. More than 1,500 private houses are not included

Comparative Vulnerability to Kobe and Neftegorsk Earthquake Disasters

Indicator	Neftegorsk*	Kobe*
Number of people killed (‘000)	~ 2000	~6500
As percentage of the total population	72	0.4
Direct economic losses (US$ million)	100	114,000
Recovery potential	Zero	Full

* Rounded numbers

(C) Catastrophic Floods in Yakutia, May-June 1998

A Snapshot of Yakutia

Territory ('000 km^2)	3,103
Population (million)	1.07
Population density (people/ km^2)	0.4
Temperature in:	
January	-28C / -50C
July	+2C / +19C

Impact and Damage

Districts affected	
Number	20
% of the total	58
Communities affected	
Number	171
Number of people	~ 500,000
Killed	19
Evacuated	51,000
Homeless	47,773
Number of the damaged buildings and facilities	
Residential (houses)	15,245
Industrial units	914
Social infrastructure units	456
Boiler-houses	130
Bridges	312
Dams	213
The worst affected small town (Lensk)*	
Population	38,000
% of the town area inundated	72
% of the houses partially damaged	92

* In Spring 2001 catastrophic floods of the same severity completely destroyed Lensk

(D) Catastrophic Floods in the South of Russia, 2002

Impact and Damage

Territory affected	Nine regions with a total population of ~ 11 million people
Number of communities affected	303
Number of people	> 500,000
Killed	114
Evacuated	106,000
Homeless	> 400,000
Houses damaged	40,463
Houses totally destroyed	7,703
Direct economic losses (US$ million)	470

Recovery Potential Estimate (months)

Rehabilitation of the main lifelines (water, electricity, gas) and roads*	1.0 – 1.5
Rehabilitation of houses**	12 – 18
Full rehabilitation of property including, belongings, live-stock***	48 – 60

*Estimate based on official EMERCOM data on the pace of recovery works
** The Order of the President of Russia
*** Estimate based on the ratio between actual compensation allowances and value of property loss