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SEISMIC RISK CARTOGRAPHIC VISUALIZATION FOR CRISIS MANAGEMENT

ABSTRACT. Earthquake loss estimations before future events and following strong earthquakes in emergency mode and their corresponding visualization are extremely important for proper decision on preventive measures and effective response in order to save lives and properties. The paper addresses the methodological issues of seismic risk and vulnerability assessment, mapping with GIS technology application. Requirements for simulation models, databases used at different levels, as well as ways of visualizations oriented for Emergency Management Agencies, as well federal and local authorities are discussed. Examples of mapping at the different levels: global, country, region and urban one are given and the influence of input data uncertainties on the reliability of loss computations is analyzed.

KEY WORDS: earthquake loss estimation, maps of risk and vulnerability, support of decision making.

INTRODUCTION

Earthquakes are among the most damaging natural phenomena striking mankind; when occurring in a densely populated territory, they can prove devastating. They are sudden and not predictable in the present scientific context, in the sense that scientists are not yet in the position of warning efficiently the exposed populations that an event is being prepared in the short term.

Progress will obviously come from a better understanding of the physical processes at earthquake source, as well as a finer knowledge of wave propagation and of interaction of waves with artifacts. In order, for the authorities in-charge and emergency managers, to be really efficient when confronted to a strong event just occurred or expected, they should be provided with the necessary data and models to estimate the potential damage caused by an earthquake occurring in a specific environment. Models and corresponding codes must be worked out, tested and improved; naturally, data is required. Most often, data needed shows specific features: extremely bulky, accumulated and stored locally, eventually restricted in its use by the owners if not simply unavailable.

Nevertheless, the potential impact of large earthquakes can be reduced by implementing preventive measures' plans based on seismic risk maps and timely and correct action just after a disastrous earthquake.

The paper discusses methodological issues for earthquake loss assessment, requirements for simulation models and databases used at different levels, as well as ways of visualizations oriented for different end-users, first of all for emergency managers and authorities in-charge. Examples of seismic risk and vulnerability mapping with Extremum Family Systems' application [Sushchev et al., 2010] are given, and the influence of input data uncertainties on the reliability of loss computations is analyzed.

PROCEDURE OF SEISMIC RISK AND VULNERABILITY ASSESSMENT

In Russia as in many countries the methods of risk assessment and mapping with the help of GIS technology have been developed taking into account the general concept adopted by UN experts [Karnik & Algermissen, 1978; Fournier d'Albe, 1982; Karnik, 1984; Boissonnade & Shah, 1984; Mitigating ..., 1991; UNISDR...., 2009; Risk..., 2010; Ranguelov, 2011] that seismic risk R_S

$$R_S = HV_S(I) \quad (1)$$

where – $V_S(I)$ is the seismic vulnerability of elements at risk (population and built environment) for the considered settlement; – H is the probability of seismic event *per* one year.

According to ISO 31010, risks are the combination of the consequences of an event or hazard and the associated likelihood of its occurrence. EU Guidelines on Risk Assessment and Mapping for Disaster Management (http://register.consilium.europa.eu/pdf/en/10/st17/st17833.en10.pdf) built on experience about existing good practice of risk assessments for major natural disasters available in Member States and developed by the end 2010 also follow the same concept.

More often two seismic risk indexes, such as individual and collective risk created by earthquakes, are considered. For estimation risk indexes and risk mapping the probabilistic approach is used. Individual risk due to seismic hazards R_S may be determined as the probability of fatalities R_S1; probability of fatalities and injuries R_S2, probability of fatalities, injuries and homeless R_S3 due to earthquakes within one year at a given place.

Collective risk due to seismic hazards R_{SC} may be determined as the expected number of fatalities $R_{SC}1$; the expected number of fatalities and injuries $R_{SC}2$; the expected number of fatalities, injuries and homeless $R_{SC}3$ as a result of earthquakes' occurrence *per* year.

Speaking about seismic vulnerability, the authors use both concepts of fragility and vulnerability. Vulnerability may be estimated through physical and economical domains. Physical vulnerability $V_{ph}(I)$ is an index, which characterizes the loss of functional properties of the considered element at risk. In the case of buildings it may be estimated as a ratio between the expected number of damaged buildings of a certain type due to earthquakes with intensity/and total number of buildings belonging to this type.

When solving some problems the physical vulnerability of buildings can also be characterized by the average damage state of buildings $d_{average(I)}$ at seismic intensity I. For example, this indicator is used for visualization on maps the extent of damage to building stock in settlements [Larionov et al. 2003a, 2003b].

Economic vulnerability for buildings of different types $V_e(I)$ is characterized by ratio between the cost of repair and the initial cost of construction [Larionov et al. 2003a, 2003b, 2006; Frolova et al. 2003a; 2007].

The fragility laws are understood as the dependence-ships between the probability of buildings belonging to different types to be damaged (the probability P_{Ai} (I) of damage state not less than given value I; and probability P_{Bi} (I) of definite damage state), and the intensity of shaking in grades of seismic scales. In the special GIS-projects for earthquake risk and vulnerability assessment at different levels, fragility laws and vulnerability functions are used for different building types classified according to MMSK-86 scale [Shebalin et al. 1986]:

- buildings types A1, A2 (from local materials);
- buildings types B, B1, B2 (brick, hewn stone or concrete blocks);

Table 1. Comparison of building vulnerability classes according to MMSK-86 and EMS-92

Description of buildings' types according to EMS-98	Vulnerability class	
	EMS-98	MMSK-86
Rubble stone, field stone	A	A
Adobe (earth brick)	A	A
Simple stone	B	A
Massive stone	C	B
Unreinforced (bricks/concrete blocks)	B	B
Unreinforced (brick) with RC floors	C	B
Reinforced or confined	D	C
Reinforced without earthquake-resistant design (ERD)	C	C
Reinforced with minimum level of ERD	D	E7
Reinforced with average level of ERD	E	E8
Reinforced with high level of ERD	F	E9
Timber structures	D	C-E7

- buildings types C, C1, C2 (reinforced concrete, frame, large panel and wooden);
- buildings types E7, E8, E9 (designed and constructed to withstand the earthquakes with intensity 7, 8, 9).

The fragility laws and vulnerability functions are usually constructed on the basis of statistical analysis of strong earthquakes engineering consequences in the regions under study. In spite on the fact of great economic and social losses caused by the strong earthquakes worldwide, there is no comprehensive information on the behavior of different types of buildings, structures and other elements of risk for large values of the damage degrees *d* and for some countries there is no statistical data at all. In the case the data on engineering consequences of strong events are not available, seismic intensity scales may be used to compensate for the lack of information gained through direct surveys. Seismic intensity scales provide the descriptions, which summarize statistical data on different buildings behavior during recent strong earthquakes in various earthquake-prone areas worldwide. For instance, European Macroseismic Scale EMS-98 contains information on all of damage states to buildings of traditional construction and earthquake-resistant buildings with a description of their behavior during earthquakes of varying intensity *I*. To ensure comparability of vulnerability functions obtained using different scales, the expert estimation of different building types according to different scales should be undertaken. Table 1 gives an example for MMSK-86 and EMS-92 scales.

TOOLS FOR RISK AND VULNERABILITY MAPPING

The section describes details of mathematical models, as well as the risk and vulnerability visualization methods at different levels.

In order to produce the maps of risks and vulnerability for the territory under study the special GIS projects are usually developed. They include data bases with information describing the considered territory with corresponding level of details, software assigned for hazard and risk indexes' assessment, interface which allows thematic maps and text report according to established forms to be produced. The software usually allows:

- to obtain the distribution of earthquake intensities (Fig. 1) and peak ground motion accelerations;

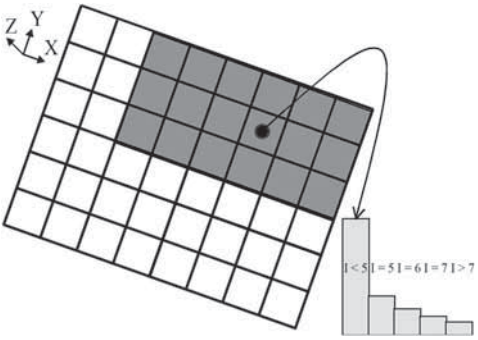

Fig. 1. Probabilistic presentation of seismic hazard information in Extremum System

- to determine the fragility laws and vulnerability functions for the buildings and structures of different type (Fig. 2) which are characteristic for the considered area, as well as for the other elements of infrastructure;

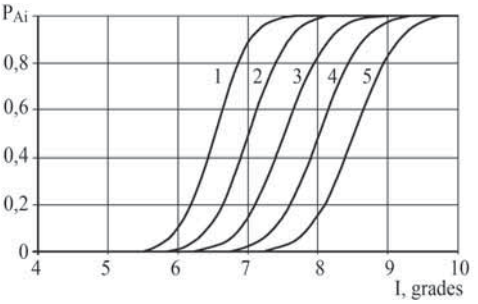

Fig. 2. Fragility laws for *B* type buildings (MMSK-86):

probability of damage state not less than given value; 1, 2, 3, 4, 5 – buildings damage states P_A

- to determine the vulnerability functions and laws of earthquake impact on population (Fig. 3);

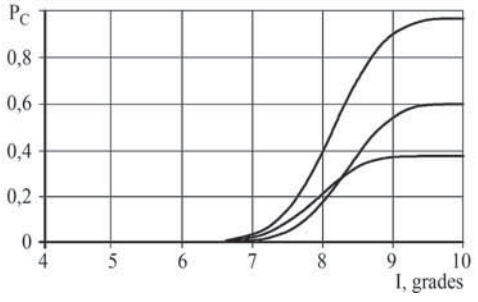

Fig. 3. Laws of earthquake impact on people in *B* type buildings:

1 – total social losses; 2 – injuries; 3 – fatalities

- to estimate damage due to scenario events according to the maps of seismic zoning or possible earthquake source zones maps;
- to estimate damage due to just occurred and scenario earthquakes, as well as and co-lateral hazards;
- to compute individual and collective seismic risk and risks due to other hazards;
- to compute individual and collective integrated risks.

For possible earthquake consequences assessment at different levels the proper databases and mathematical models should be chosen taking into account the end user requirements about the details of expected results. The table 2 shows the relationship between the details of mathematical models and the level at which the problem should be solved.

The reliability of loss and risk assessment in both modes: emergency and preventive one, strongly depends on [Bonnin et al., 2002a, b; 2004; Frolova et al., 2003a]:

- completeness and reliability of databases on elements at risk (population and built environment) and hazard sources;
- reliability of vulnerability functions and fragility laws of elements at risk;
- errors in strong earthquakes' parameters determination by Alert Seismological Surveys for computations in emergency mode;
- relevance and reliability of seismic hazard maps with different details.

All simulation models and data bases, used for risk and earthquake consequences estimation, bring in their own uncertainties and propagate the uncertainties of the previous steps of the estimation procedure. Therefore, the process of Tools' calibration is rather complicated used at all stages from, estimating shaking intensity to

Table 2. Details of mathematical models and the forms of results visualization at different levels

Level of earthquake loss estimation	Details of models	Ways of visualization on maps
Global	Usage of macro indexes based on countries economic development; Usage of averaged models of hazards and vulnerability functions	Hypsometric layers; Isolines corresponding to different values of loss and risk; Marks of different color and size
Country or Regional	Usage of regional models of hazards and vulnerability functions	Hypsometric layers; Isolines corresponding to different levels of loss and risk; Marks of different color and size
Urban	Usage of engineering methods of computations; Application of numerical methods for solving the problems	Zones (districts of settlements) of different color
Facility	Application of numerical methods for estimation of dynamic parameters of ground motion and structures strength capability; analysis of "fault and event trees"	Measurable index of damage, loss and risk; Qualitative and quantitative pattern

assessing the damage to different elements at risk. Visualization of the simulated results at each step facilitates the proper choice of calibration parameters.

EARTHQUAKE RISK AND VULNERABILITY VISUALIZATION AT DIFFERENT LEVELS

The section gives examples of the maps of seismic risk and vulnerability with different details oriented for end-users. Widely used by EMERCOM of Russian Federation ways of maps' design and production presented. Difference in maps' visualization in emergency mode and preventive one is illustrated.

Earthquake loss estimation at global level in emergency mode

The results of seismic risk assessment at global scale in emergency mode are shown on Fig. 4. The example is given for the Gansu event in China, near Minxian, on July 21, 2013. The map (Fig. 4) shows the source of hazard, epicenter of the event by special sign; isolines of different color present the macroseismic field (possible distribution of shaking intensities in grades of MMSK-86 scale); signs of different size and color stand for number of inhabitants in the settlement and average damage state. Such maps are usually accompanied by text report with estimates of expected number of fatalities, injuries and homeless for the whole stricken area and detailed description of possible consequences for each settlement in the stricken area. In the case of the Gansu earthquake, the expected number of fatalities was estimated by Global Extremum System as 46–150 people, reported 95 fatalities according to EMDAT (http://www.emdat.be/disaster_list/index.html).

Taking into account the discrepancies in earthquake parameters determination by different Seismological Surveys, regional peculiarities in shaking intensity attenuation and buildings' behavior, the loss computations are usually made for few variants and many-variants maps are produced. During the loss computations due to the earthquake on July 21, 2013 in emergency mode, information about the event parameters (coordinates of epicenter, origin time, magnitude, source depth) was taken from the following alert seismological centers: GS RAS, CEPC and NEIC. Different shaking intensity attenuation relationships and different ratio k of macroseismic ellipse major and minor semi-axis (Table 3) were used, as well as different orientation of probable anisotropic shake field when source mechanism solution became available. The macroseismic field orientation at the angle of 302° was accepted in accordance with source mechanism solution obtained by NEIC. Table 3 shows the examples of different variants for loss computation due to the earthquake on July 21, 2013.

The Global Extremum System impact database for China (Fig. 5), which includes the descriptions

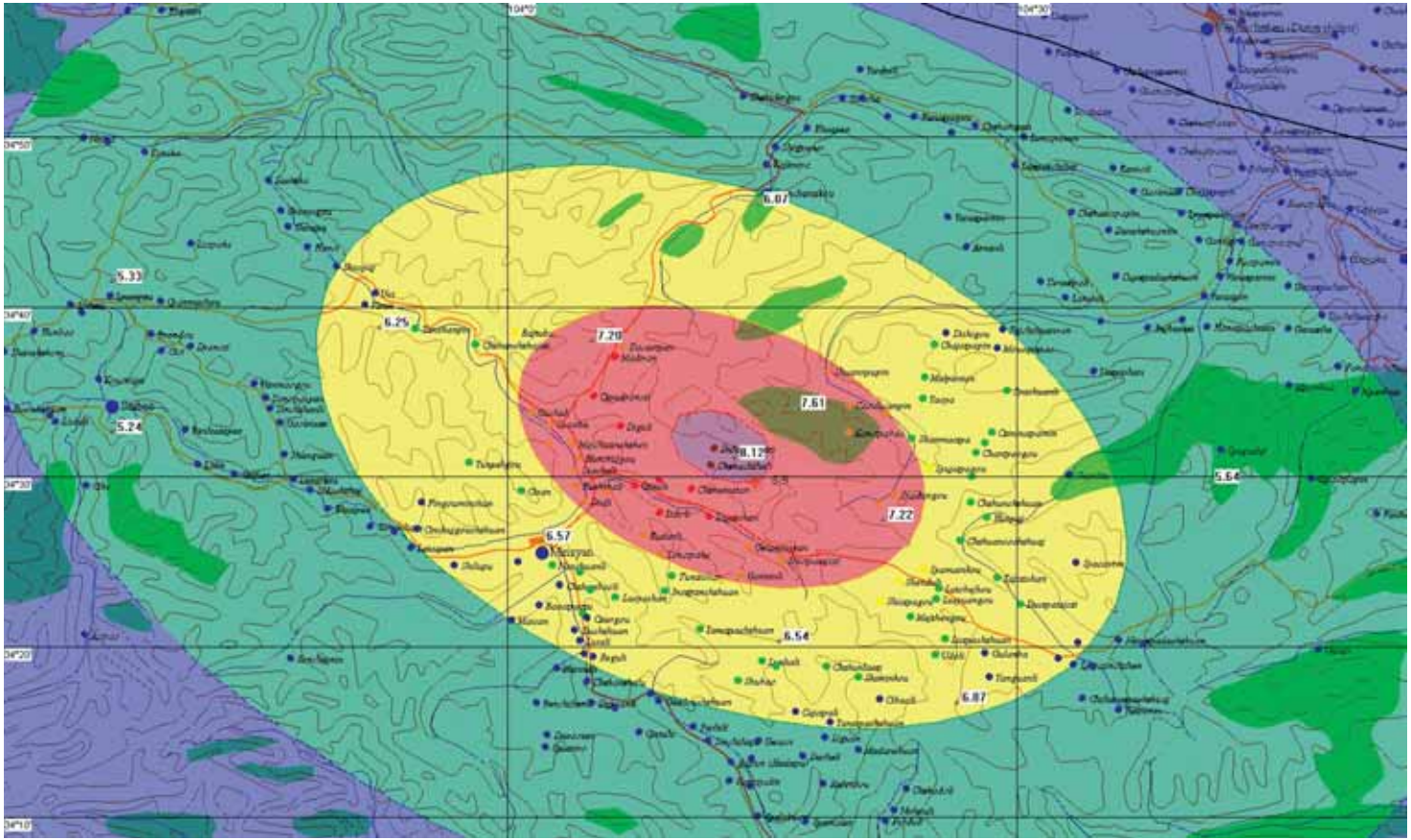

Fig. 4. Results of possible loss simulation by Extremum for the July 21, 2013 earthquake in China (variant 5, Table 3):

dots are settlements in the stricken area; colour of dots shows the average damage state of building stock (black: total collapse; brown: partial collapse; red: heavy; yellow: moderate; green: slight damage; blue: no damage); figures show the values of expected shaking intensities

Table 3. Input data for simulation of the consequences of the July 21, 2013 event in China

no.	Survey	Lat., Log.	M	h, km	equation	Ratio *k*	Ellipse orientation
1	USGS	34,499; 104,243	5.9 (M_W)	9,8	[Shebalin, 1977]	1.5	along faults
2	USGS	34,499; 104,243	5.9 (M_W)	9,8	[Shebalin, 1977]	1.5	Angle 302°
3	USGS	34,499; 104,243	5.9 (M_W)	9,8	IASPEI, 1993 Eastern part	1.5	Angle 302°
4	USGS	34,499; 104,243	5.9 (M_W)	9,8	IASPEI, 1993 Western part	1.5	Angle 302°
5	CEIC	34,5; 104,2	6.6	20	IASPEI, 1993 Eastern part	1.5	Angle 302°
6	CEPC	34,5; 104,2	6.6	20	IASPEI, 1993 Western part	1.5	Angle 302°
7	GS RAS	34,53; 104,21	6.1 (M_S)	10	IASPEI, 1993 Eastern part	1.5	Angle 302°
8	GS RAS	34,53; 104,21	6.1 (M_S)	10	IASPEI, 1993 Western part	1.5	Angle 302°
9	GS RAS	34,53; 104,21	6.1 (M_S)	10	[Shebalin, 1977]	1.5	Angle 302°
10	CEIC	34,5; 104,2	6.6	20	(Shebalin, 1977]	1.5	Angle 302°
11	CEIC	34,5; 104,2	6.6	18	[Shebalin, 1977]	1.5	Angle 302°
12	CEIC	34,5; 104,2	6.6	18	[Shebalin, 1977]	2.25	Angle 302°

of more than 100 events for the country, was used to take into account the regional peculiarities of shaking intensity attenuation.

By accumulating the data on reported consequences of strong events the results of computation (simulation) according to different variants of input data are compared with observed ones. In the case of the event on July 21, 2013 the simulated by Global Extremum System intensity estimations were compared with observed macroseismic effect published by the Chinese seismological authorities (Fig. 6) in order to find the better agreement between simulated and observed effect. The map on Fig. 6 shows isoseists with different intensities I = VIII (dark red), VII (pink) and VI (light pink). The zone with I = VIII corresponds to huge destruction, I = VII – to very strong shaking and is also responsible for a lot of misery. The yellow dot is the epicenter or breaking point. The red lines on the map are the mapped faults (http://earthquake-report.com/2013/07/21/very-strong-earthquake-gansu-china-on-july-21-2013).

Figure 7 shows the comparison of observed shaking intensity values (Fig. 6) with simulated ones using Extremum System software (Table 3) and ShakeMap software of PAGER System.

In the case of the event on July 21, 2013 all simulated values of shaking intensity are in general underestimated in comparison with observed values. The greatest difference of simulated ant observed intensities is about two grades of intensity scale. Such estimations are not acceptable as will not allow the reliable loss estimations to be achieved.

The exception is variant 5 (Fig. 5, Table 3) for the epicentral distances $\Delta > 25$ km, it gives intensity values slightly above reported ones. In the case CEIC parameters of the event are used for loss computations, ΔI_{max} do not exceed one grade of intensity scale for all variant 5, 6, 10 11 and 12 (Table 4). For the variant 5 the values of $\Delta I_{average}$ is equal to 0.1.

Relatively good agreement of simulated and observed shaking intensity values is obtained when we use the regional intensity attenuation relationships (equations 2, 3) proposed for the eastern part of China in IASPEI publication [The Practice..., 1993].

Along major axis:

$$I = 6{,}045 + 1{,}480m - 2{,}081\ln(R + 25{,}0),\quad s = 0.49 \qquad (2)$$

Along minor axis:

$$I = 2{,}617 + 1{,}435m - 1{,}441\ln(R + 7{,}0),\quad s = 0.56 \qquad (3)$$

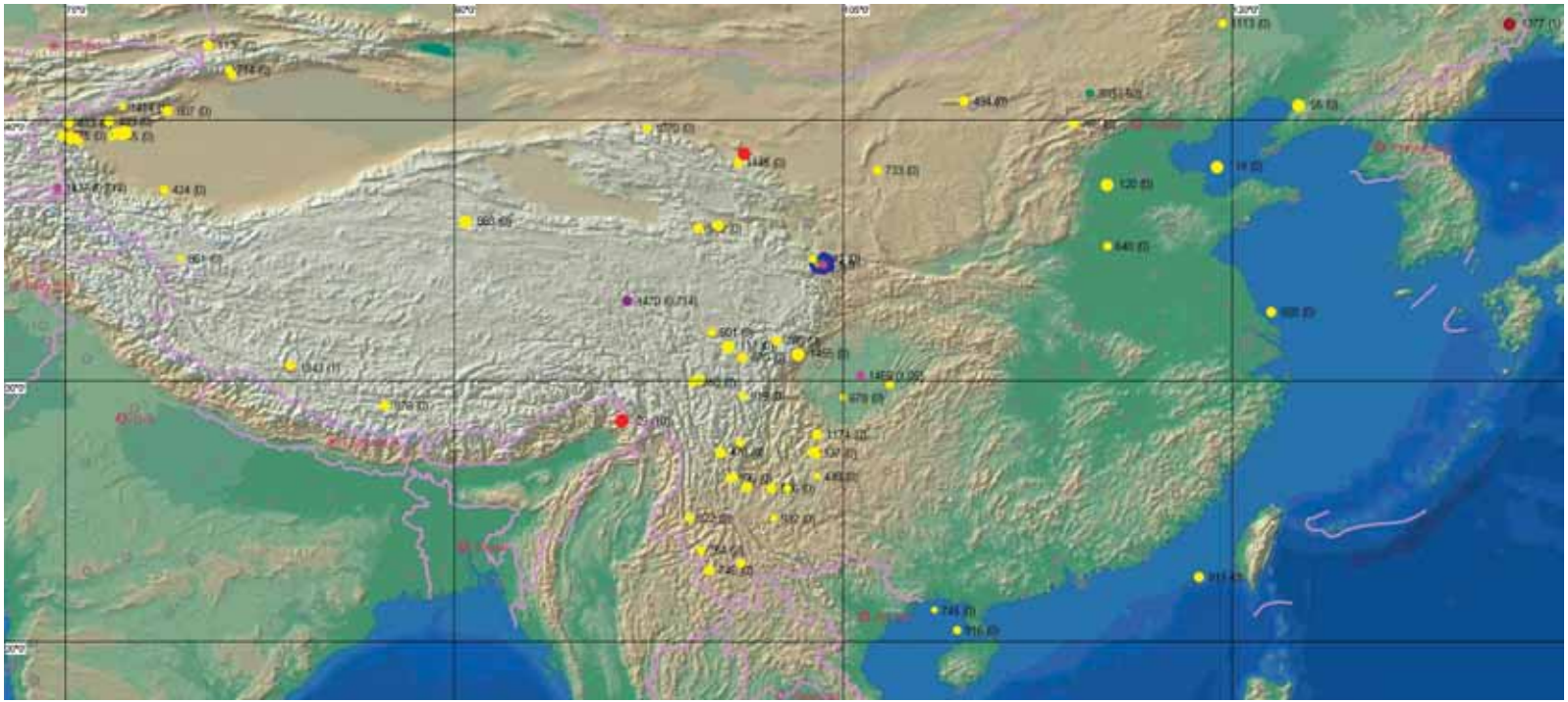

Fig. 5. Fragment of the "Extremum" System impact knowledge base about past events consequences for China

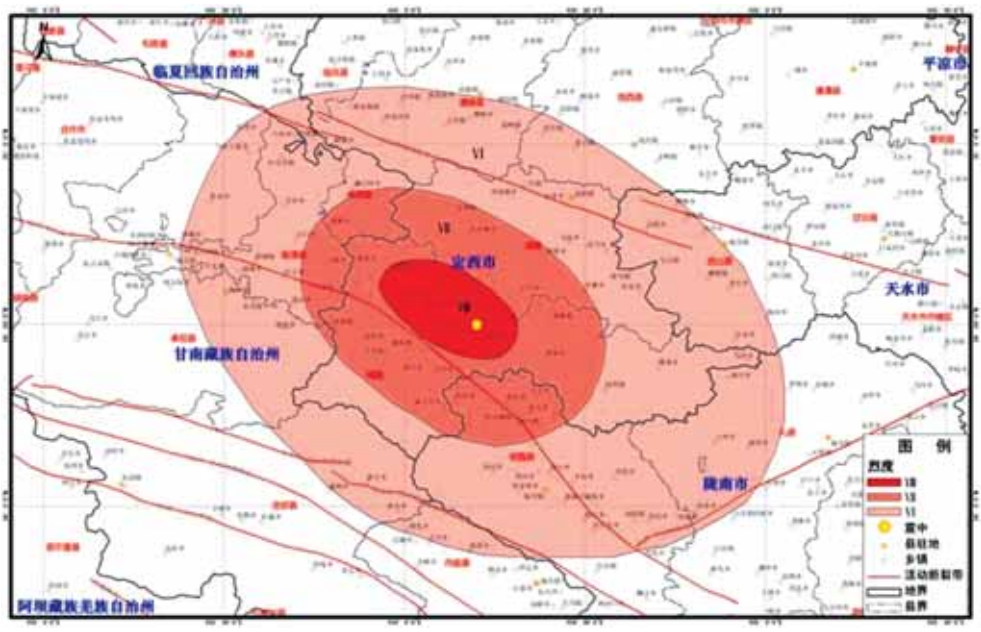

Fig. 6. The isoseismal map published by the Chinese seismological authorities for the event on July 21, 2013

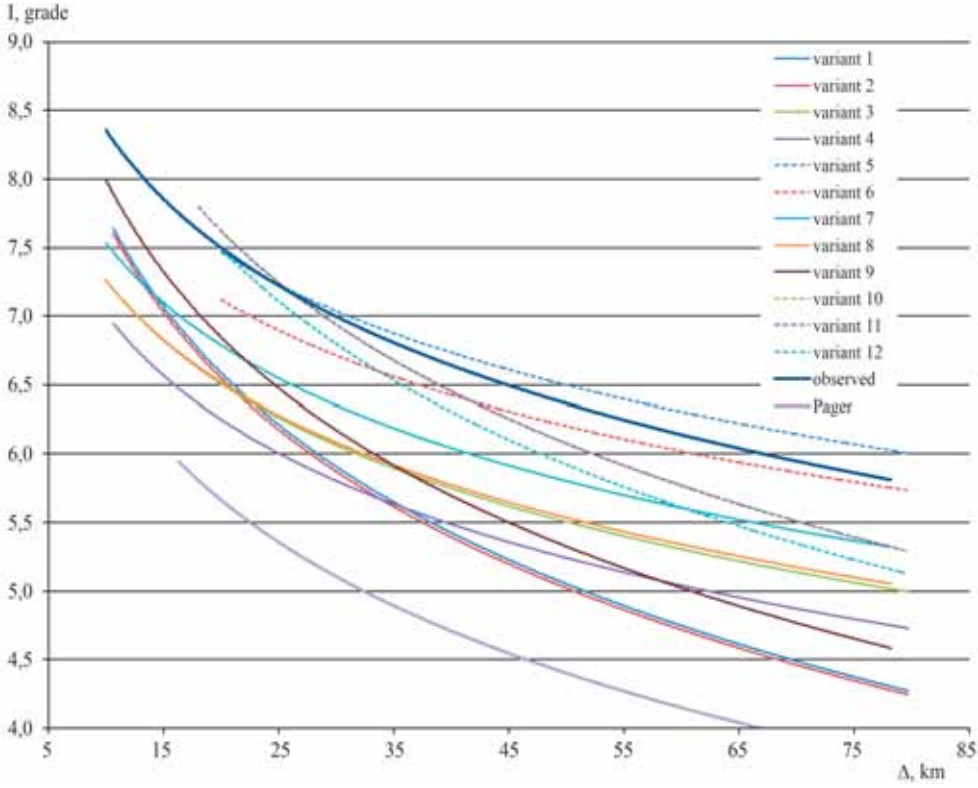

Fig. 7. Comparison of simulated shaking intensities for the event on July 21, 2013 with application of Extremum and PAGER Systems and reported values

Table 4. Comparison of intensities computed using CEPC parameters of earthquake with observed values of shaking intensity

Variant 5	Variant 6	Variant 10	Variant 11	Variant 12
$\Delta I_{max} = 1,0$ $\Delta I_{average} = -0,1$ $\sigma = 0,3$	$\Delta I_{max} = 1,0$ $\Delta I_{average} = -0,4$ $\sigma = 0,3$	$\Delta I_{max} = 1,0$ $\Delta I_{average} = -0,4$ $\sigma = 0,2$	$\Delta I_{max} = 1,0$ $\Delta I_{average} = -0,3$ $\sigma = 0,2$	$\Delta I_{max} = 1,0$ $\Delta I_{average} = -0,5$ $\sigma = 0,3$

In the case of variant 3, 5 and 7 (Table 5) ΔI_{max} varies from one intensity grade up to 1.5 and $\Delta I_{average}$ changes from 0.2 up to 0.3.

Table 5. Comparison of intensities computed using regional attenuation relationships (2 and 3) with observed values of intensity

Variant 3	Variant 5	Variant 7
$\Delta I_{max} = -1.5$ $\Delta I_{average} = -1$ $\sigma = 0.3$	$\Delta I_{max} = 1.0$ $\Delta I_{average} = -0.1$ $\sigma = 0.3$	$\Delta I_{max} = 1.0$ $\Delta I_{average} = -0.6$ $\sigma = 0.2$

Figure 8 shows the average residuals, binned in 5 km by epicentral distance, from observed and simulated shaking intensities for the variants 5 and 6, Fig. 9 – for the variants 10 and 11.

The example of this event shows the importance of proper choice of macroseismic field model: regional intensity attenuation equation and its regional coefficients; orientation and ratio *k* of ellipse major and minor semi-axis.

This event also shows the previous calibration for the area under study was successful. It was based of the past events in the Global Extremum System data bases (Fig. 5).

Visualization of loss simulation results allows the time needed for system calibration to be reduced significantly.

Seismic risk assessment at country level in preventive mode

Fig. 10 shows example of seismic risk maps of the Russian Federation territory produced within the Federal Program "Natural and Technological Risk Assessment and Management in the Russian Federation until 2010" in order to identify the most vulnerable areas and develop the preventive measures' plan aimed at risk reduction. As input data

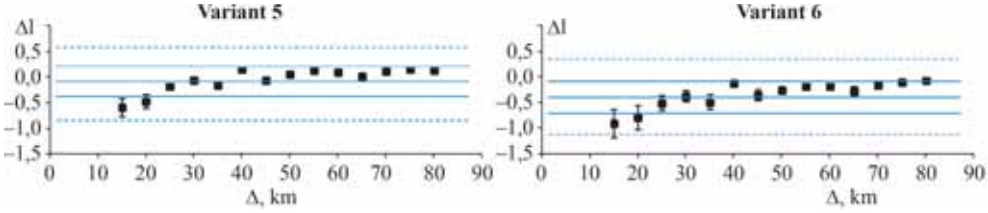

Fig. 8. Residuals for the simulated shaking intensities; residuals are binned in 5-kilometer windows and the median residual is plotted by grey dots

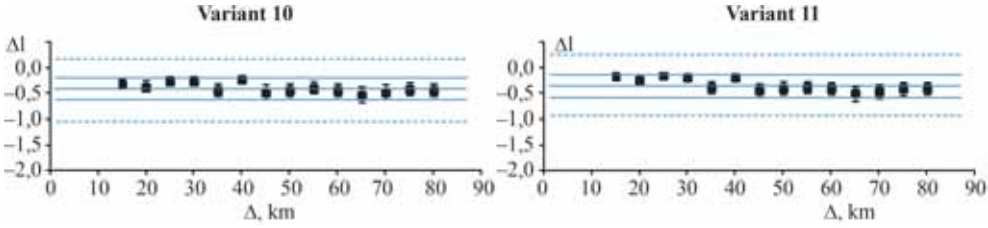

Fig. 9. Residuals for the simulated shaking intensities; residuals are binned in 5-kilometer windows and the median residual is plotted by grey dots

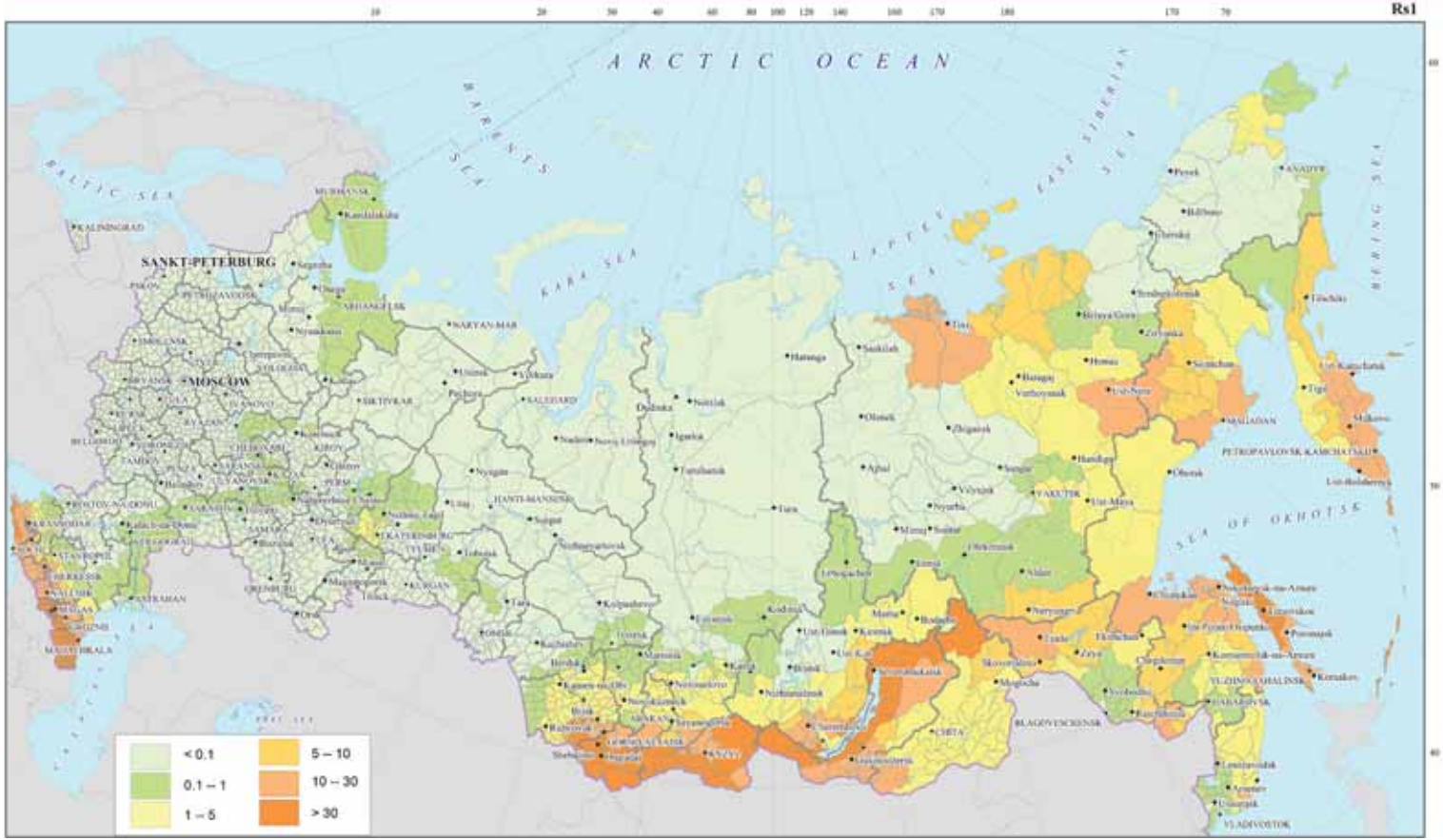

Fig. 10. Map of individual seismic risk R_s1, 10^{-5}/year, for the territory of Russian Federation

about seismic hazard the set of review seismic zoning maps (scale 1:5 000 000) were used. They are the maps of review seismic zoning of the OSR-97 A, B and C, corresponding to 10 % (A), 5 % (B) and 1 % (C) probability of exceeding the calculated intensity for a fixed interval of time T = 50 years, or 90 % probability of not exceeding the values of intensity for the following fixed time intervals, respectively, T = 50 (A), 100 (B) and 500 (C) years [Set ..., 1998]. The built environment was presented by averaged settlements models: percent of building of different types according to MMSK-86 scale and their average height. On the whole within the Program six maps of individual risk R_S (Fig. 10) and collective risk R_{SC} have been constructed: R_S1, R_S2, R_S3; $R_{SC}1$, $R_{SC}2$, $R_{SC}3$. Values of seismic risk obtained for separate cities and settlements were averaged within the administrative regions of the country and are shown on the maps by different color. The color scale is usually chosen in order to pay attention of the end-users to the areas characterized by high risk level.

Obtained values of individual seismic risk R_S vary from negligible ones close to zero up to rather high values – more than $30 \cdot 10^{-5}$ for the probability of fatalities (map R_S1), more than $100 \cdot 10^{-5}$ for the probability of fatalities and injuries (map R_S2), more than $150 \cdot 10^{-5}$ for the probability of fatalities, injuries and economic loss to population caused by earthquakes per year (map R_S3).

Table 6 shows size of zones with different levels of individual seismic risk according to maps R_S1, R_S2 and R_S3.

Obtained values of collective seismic risk R_{SC} vary from negligible small ones – less than $0.1 \cdot 10^{-5}$ up to rather high values –

Table 6. Values of individual seismic risk and size of zones with different risk levels

Risk ranges, 10^{-5}, 1/year	Qualitative risk characteristics	Square of zones, map R_S1, %	Square of zones, map R_S2, %	Square of zones, map R_S3, %
Less than 0.1	small	53	49	46
0.1–1.0	moderate	15	17	13
1.0–5.0	average	14	9	11
5.0–10.0	high	7	8	5
10.0–30.0	rather high	7	9	11
30.0–100.0	extremely high	3	7	10
100.0–150.0		–	1	1
More than 150.0		–	–	2

Table 7. Values of collective seismic risk and size of zones with different risk levels

Risk ranges, persons/year km^2	Qualitative risk characteristics	Square of zones		
		map $R_{SC}1$, %	map $R_{SC}2$, %	map $R_{SC}3$, %
Less than 0.1	small	58.4	53.6	48.8
0.1–1.0	moderate	15.1	14.5	16.9
1.0–5.0	average	12.7	12.0	9.6
5.0–50.0	high	10.2	13.3	15.7
50.0–500.0	rather high	3.0	5.4	7.2
500.0–1,000.0	extremely high	0.4	0.5	0.6
1,000.0–5,000.0		0.4	0.5	0.6
More than 5,000.0		–	0.2	0.6

more than $1{,}000 \cdot 10^{-5}$ for expected number of fatalities (map $R_{SC}1$), more than $5{,}000 \cdot 10^{-5}$ for expected number of fatalities and injuries (map $R_{SC}2$) and for expected number of fatalities, injuries and number of persons who lost their property (map $R_{SC}3$). Table 7 shows size of zones with different levels of collective seismic risk according to maps $R_{SC}1$, $R_{SC}2$ and $R_{SC}3$.

The computed values of individual seismic risk R_S1 are more than $30.0 \cdot 10^{-5}$, 1/year for all administrative divisions within Sakhalin area, Republic of Altaj, Tyva, Dagestan and Northern Osetiya. The highest values of individual seismic risk R_S3 are obtained for Kamchatka, near lake Baikal, Republic of Buryatiya, Irkutsk region, Altaj kraj, as well as for Krasnodar region and Chechen Republic. Table 8 shows the values of individual seismic risk R_S1 for some administrative areas of the Russian Federation.

Table 8. Individual seismic risk R_S1 for some administrative units of the Russian Federation

Administrative unit of RF	Name of municipal region	Population, persons	Population density, persons/km^2	Seismic risk $R_S1{,}1 \cdot 10^{-5}$, 1/year
Altajsky kraj	Petropavlovsky rajon	11,915	7.36	33.4
	Soloneshensky rajon	9,848	2.79	43.5
	Ust-Kalmansky rajon	14,450	6.28	31.7
	Xharyshsky rajon	11,728	1.7	30.2
Republic of Buryatiya	Barguzinsky rajon	22,738	1.23	43.7
	Ivolginsky rajon	42,665	15.8	30.4
	Kabansky rajon	58,340	4.32	44.3
	Kurumkansky rajon	14,376	1.15	46.1
	Mujsky rajon	11,218	0.45	47.6
	Okinsky rajon	5,395	0.21	45.0
	Pribajkalsky rajon	26,840	1.73	42.7
	Severo-Bajkalsky rajon	13,181	0.24	49.6
	Tunkinsky rajon	21,778	1.85	43.2
Zabajkalsky kraj	Kalarsky rajon	9,600	0.17	55.1
Republic of Ingishetiya	Malgobeksky rajon	52,038	77.67	34.2
	Nazranovsky rajon	94,254	134.65	31.3
	Sunzhensky rajon	121,079	80.03	34.8
Irkutsk oblast	Olkhonsky rajon	9,998	0.57	46.7
	Sluydyansky rajon	42,331	8.25	39.8
	Shelekhovsky rajon	63,876	30.42	31.7
Kamchatsky kraj	Elizovsky rajon	64,262	1.57	60.4
Krasnodarsky kraj	Town-resort Anapa	167,095	170.16	32.5
	Town-resort Gelendzhik	104,439	85.05	31.6
	Novorossijsk City	313,307	375.22	31.8
	Tuapsinsky rajon	129,066	53.7	33.3
Chechen Republic	Achkhoj-Martanovsky rajon	83,604	76	36.8
	Vedensky rajon	38,378	40.14	39.8
	Itum-Kalinsky rajon	5,888	2.94	40.0
	Novolaksky and Nozhaj-Yurtovsky	53,821	85.57	38.3
	Urus-Martanovsky rajon	130,997	201.53	37.7

Seismic risk maps of the Russian Federation are usually produced every 10–15 years taking into account updated estimations of seismic hazard level for the country territory and amortization of built environment. Such maps are used for creating schemes of territorial planning of preventive measures and their implementation. Risk visualization with such details allows the regions to be identified (Table 8), where more detailed information on hazard level and buildings inventory is needed for risk assessment at regional level.

Seismic risk and vulnerability assessment and mapping at regional level

Regional maps of seismic risk are usually constructed for the territories with high level of risk (more than $1 \cdot 10^{-5}$) in order to verify averaged estimations obtained at country level. As input data about seismic hazard the maps of review (scale 1:5,000,000) and regional detailed seismic zoning (scale 1: 500,000 or 1:200,000), as well as the shaking intensities' matrixes for the area under study are used. The built environment for cities and large settlements are verified and updated averaged settlements models (percent of building of different types according to MMSK-86 scale and their average height) are created.

To construct the regional seismic risk R_S1 maps for the population of the Irkutsk oblast, the Republic of Buryatiya and the Chita oblast two types of data about seismic hazards level were used. They are the set of maps of review seismic zoning of the OSR-97 A, B and C [Set ..., 1998] and the the shaking intensities' matrixes provided by the Institute of the Earth's Crust, Siberian Department of RAS.

The following procedure [Bonnin et al., 2002b; Bonnin & Frolova, 2004; Bonnin & Frolova, 2010; Frolova et al., 2003b; Frolova et al., 2006; Frolova et al., 2010; Larionov & Frolova, 2003a; Larionov et al., 2003b] was implemented to determine the risk indexes: identification of the quantitative characteristics of the seismic hazard for each settlement; computation of the damage states probability distribution for buildings of different types for various values of shaking intensity; computation of the possible social losses – the distribution of fatalities for each settlement; computation of the probability of fatalities per definite time period and per one year for each settlement. For computation of expected social losses for large towns and cities they were divided into elementary units, and their coordinates were represented by a point located in the center of the unit. Then the risk values obtained for individual unit sites were summarized. Fig. 11 and 12 show the examples of individual seismic risk zoning R_S1 maps for the Irkutskaya oblast, the Republic of Buryatiya and the Chitinskaya oblast produced using the map of review seismic hazard and shaking intensities' matrixes.

The regional maps of risk zoning (Fig. 11–12) includes two elements: risk for settlements with number of inhabitants less than 1,000, shown by "hypsometric" contours, and risk for settlements with number of inhabitants more than 1,000 shown by symbols (circles of different sizes and colors). The "hypsometric" scale is used to represent both elements on the map.

For the majority of settlements the seismic risk values R_S1 obtained using the shaking intensities' matrixes are less than the values obtained with the use of map OSR-97 (Table 9). On the whole, the values of seismic risk are still rather high for the considered area.

Fig. 13–15 presents the examples of regional maps of seismic vulnerability for the Northern Caucasus. As input data about seismic hazard the map of review (scale 1:5,000,000) seismic zoning OSR-97B is used. Maps include two elements: percent of different damage states for settlements with number of inhabitants less than 1,000 and vulnerability for cities and towns with number of inhabitants more than 1,000. Physical vulnerability $V_{ph}(I)$ is presented as circle (Fig. 13) and bar charts (Fig. 14).

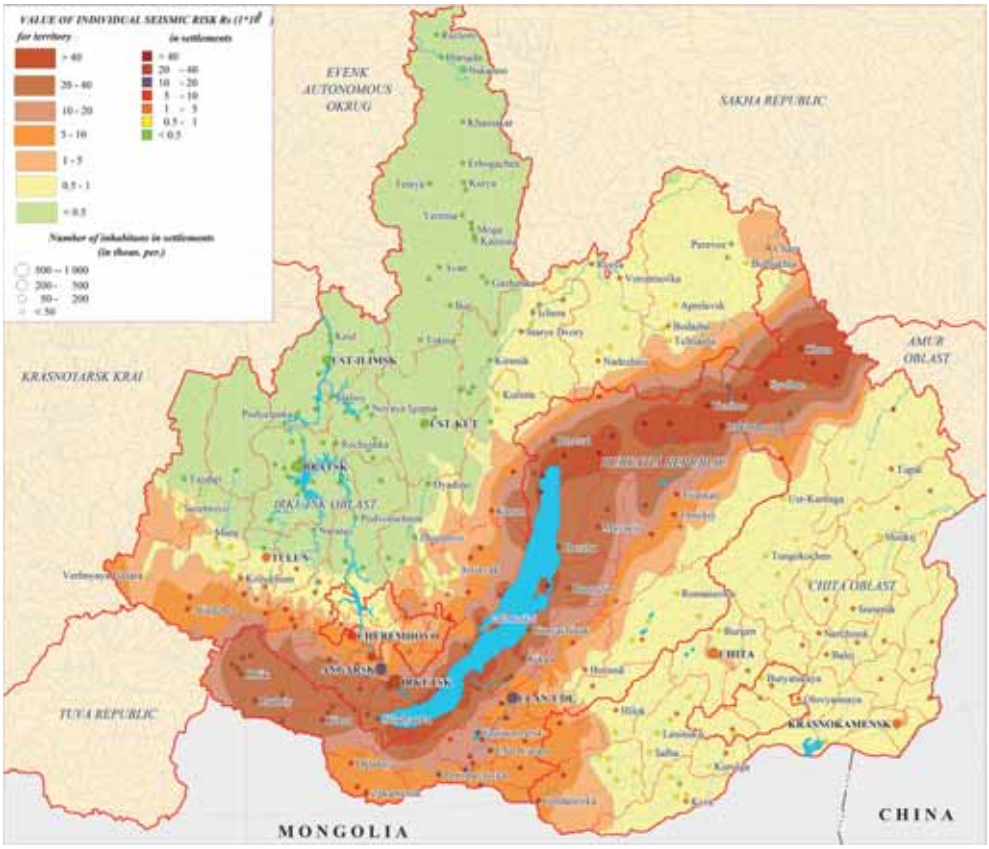

Fig. 11. Seismic risk map using the maps OSR-97

Table 9. Values of individual seismic risk R_s1 using shaking intensities' matrixes and maps OSR-97 for some cities and towns of the Baikal region

Name of settlement	Administrative unit of the Russian Federation	Population, thousands persons	R_s1 using matrices, 10^{-5} 1/year	R_s1 using OSR-97 maps, 10^{-5} 1/year
Irkutskк	Irkutsk oblast	583	13.1	42.1
Ulan-Ude	Republic of Buryatiya	367	19.1	28.3
Chita	Chita oblast	300	0.9	6.51
Angarsk	Irkutsk oblast	247	17.2	30.6
Shelekhov	Irkutsk oblast	48	20.5	61.2
Gusinoozersk	Republic of Buryatiya	28	14.2	28.3
Severobajkalsk	Republic of Buryatiya	27	78.2	56.6
Sludyanka	Irkutsk oblast	19	65.4	61.2
Kyakhta	Republic of Buryatiya	18	17.8	28.28
Selenginsk	Republic of Buryatiya	17	60.51	56.55
Bajkalsk	Irkutsk oblast	14	58.92	61.24
Toksimo	Republic of Buryatiya	12	72.25	56.55

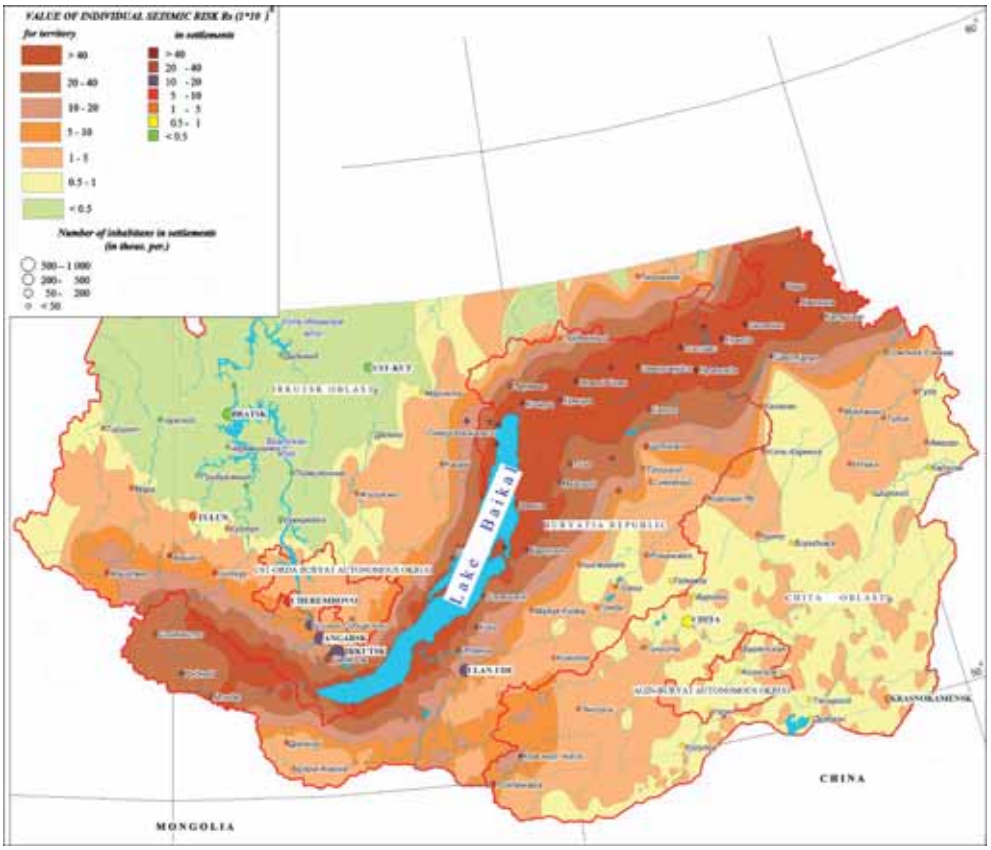

Fig. 12. Seismic risk map using the shaking intensities' matrixes

Maps of physical vulnerability may be used for preventive measure plans development and implementation at region level (Fig. 13) and for taking decision about population evacuation as it takes into account 3 damage states which result in estimation of homeless people (Fig. 15). Visual analysis of these maps give an evidence that the percent of damage states equal to 3–5 is rather high for some settlements. This fact allows making a conclusion that the preventive measures in these settlements are not sufficient.

Fig. 15 shows the map of economic vulnerability $V_e(I)$ for the Northern Caucasus, which is characterized by ratio between the cost of buildings repair and the initial cost of their construction. As previous maps, it also includes two elements: ratio between the cost of buildings repair and the initial cost of their construction for settlements with number of inhabitants less than 1,000 is shown by zones of different colors and the ratio for cities and towns with number of inhabitants more than 1,000 is shown by figures.

Tables 10–11 show the average values of damage states $d_{average}(I)$ to build environment and average values of economic vulnerability $V_e(I)$ for the administrative areas in the Northern Caucasus.

Regional maps of seismic risk and vulnerability allow settlements to be identified when additional study should be undertaken. First of all, the maps of seismic microzoning of the settlement territory should be compiled. The data on built environment inventory should be verified by visual inspection or by a joint analysis of high-resolution space images and photo panoramas of settlements.

Fig. 13. Fragment of the physical vulnerability map for the Northern Caucasus Federal region of the Russian Federation and Krasnodar area: percent of buildings in settlements which may survive damage states *d* = 1, 2, 3, 4, 5 in the case of earthquakes according to the seismic hazard map OSR-97B:

light blue – no damage; blue – light damage; green – moderate; yellow – heavy; brown – partial collapse; pink – total collapse

Fig. 14. Fragment of the physical vulnerability map for the Northern Caucasus Federal region of the Russian Federation and Krasnodar area: percent of buildings in settlements which may survive damage states d = 3, 4, 5 in the case of earthquakes according to the seismic hazard map OSR-97B:

light blue – no damage; blue – light damage; green – moderate; yellow – heavy; brown – partial collapse; pink – total collapse

Fig. 15. Fragment of economic vulnerability map in relative units:

figures – ratio between the cost of building repair and the initial cost of its construction

Table 10. Average damage states to buildings and structures in the administrative units

Administrative unit	Population, persons	Population density, persons/km^2	Average damage states $d_{average}$ (I)
Krasnodar kraj	5,404,273	71.59	2.2
Republic of Dagestan	2,963,918	58.96	3.9
Republic of Adygeya	446,406	57.29	3.1
Republic of Ingushetiya	453,010	124.86	4.5
Kabardino-Balkar Republic	858,397	68.84	3.5
Karachaevo-Cherkessk Republic	469,837	32.91	3.6
Republic of North Osetiya – Alaniya	703,977	88.14	4.7
Stavropol kraj	2,794,508	42.24	2.1
Chechen Republic	1,346,438	86.05	3.9

Table 11. Average values of economic vulnerability in the administrative units

Administrative unit	Population, persons	Population density, persons/km^2	Average value of economic vulnerability $V_e(I)$
Krasnodar kraj	5,404,273	71.59	0.4
Republic of Dagestan	2,963,918	58.96	0.8
Republic of Adygeya	446,406	57.29	0.5
Republic of Ingushetiya	453,010	124.86	0. 9
Kabardino-Balkar Republic	858,397	68.84	0.7
Karachaevo-Cherkessk Republic	469,837	32.91	0.7
Republic of North Osetiya – Alaniya	703,977	88.14	0.9
Stavropol kraj	2,794,508	42.24	0.3
Chechen Republic	1,346,438	86.05	0.7

Seismic risk assessment at urban level

In the case of medium-term earthquake prediction for urbanized area, such as Petropavlovsk-Kamchatsky, or in the case of large investment projects in areas characterized by high level of seismic hazard, such as the Olympic Games Complex in City Big Sochi, the maps of seismic risk are constructed for definite cities. As input data about seismic hazard the maps of seismic microzing (scale 1:10,000) are used. The building inventory for cities is verified and updated averaged city districts models (percent of buildings of different types according to MMSK-86 scale within city district and their average height) or building by building inspection is undertaken in order

Fig. 16. Fragment of high-resolution space image for City Big Sochi, Kirova street

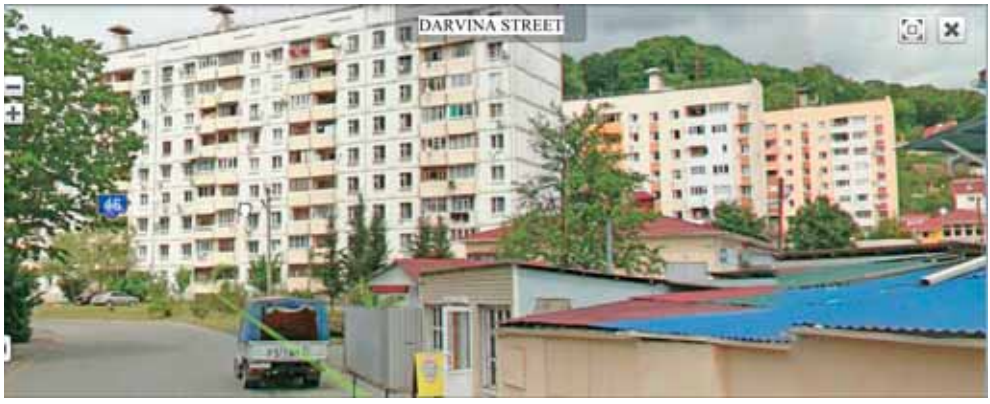

Fig. 17. Fragment of photo panorams from http://maps.yandex.ru/ for City Big Sochi, Darvina street

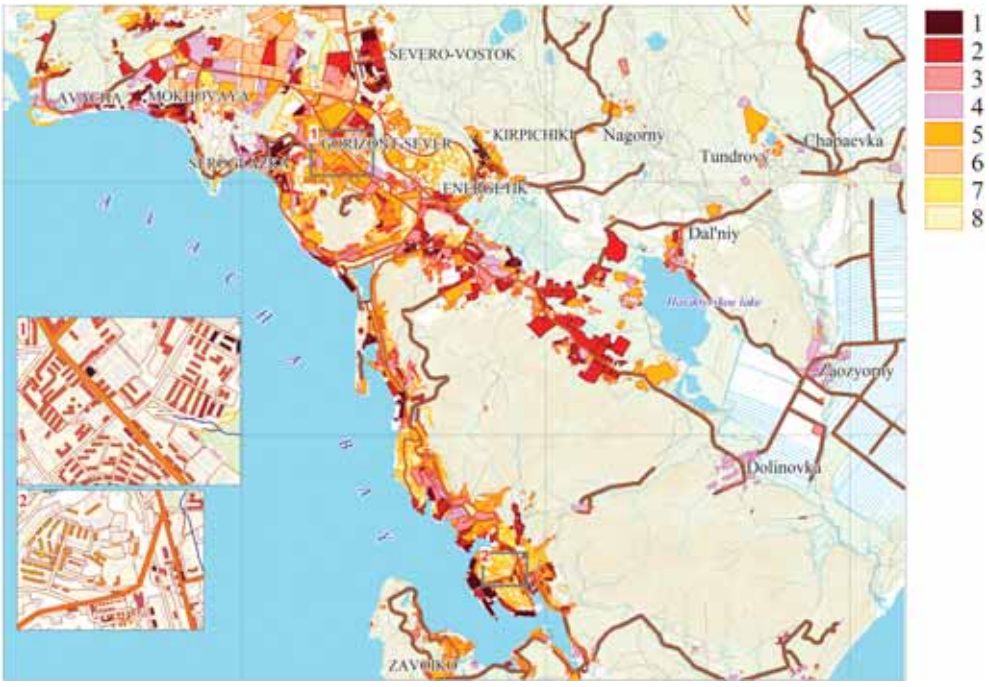

Fig. 18. Location of scenario earthquakes' source zones:

1 – VUL; 2 – PET; 3 – AVG; 4 – AVS; 5 – FZ9; 6 – FZ8; 7 – axis of the Pacific Ocean deep-water trough

to collect information about each building. Together with land inspection, decoding of high resolution space images and web-mapping may be applied (Fig. 16 and 17) for verification data on built environment inventory.

As an example of seismic risk computations at urban level the Petropavlovsk-Kamchatsky City is used. The Kamchatka Peninsula territory is one of the most seismically active regions of the Russian Federation. The land inspection was undertaken to verify the data on each building in the city. The Institute of Physics of the Earth, Russian Academy of Sciences, identified six possible earthquake source zones (VOZ). The values of M_{max} and return periods for the possible events in these zones VOZ (Fig. 18) are given in Table 12.

The results of seismic risk computation for different VOZ zones (Table 12) show that the highest values of risk for population are reached for an event in zone AVS

Table 12. Expected social losses and individual risk R_s1 for the Petropavlovsk – Kamchatsky city due to events in different zones VOZ

Zone index	M_{max}; Return period, years	Seismic Individual Risk, 10^{-5}	Expected Losses	
			Fatalities, persons	Injuries, persons
PET	6.8–7.0; 3 000–30 000	1.0–8.0	7,260–15,460	16,180–33,120
VUL	6.8–7.0; 2 000–20 000	1.0–10.0	5,590–12,860	12,580–32,310
FZ9	9.0–8.5; 100–500	8.0–50.0	44–290	250–1 320
FZ8	8.4–8.25; 50–500	10.0–45.0	220–810	720–3,270
AVS	7.8–7.9; 30–100	30.0–300.0	850–2,610	2,450–8,150
AVG	7.8–7.9; 300–3 000	4.0–15.0	570–1,760	1,650–6,330

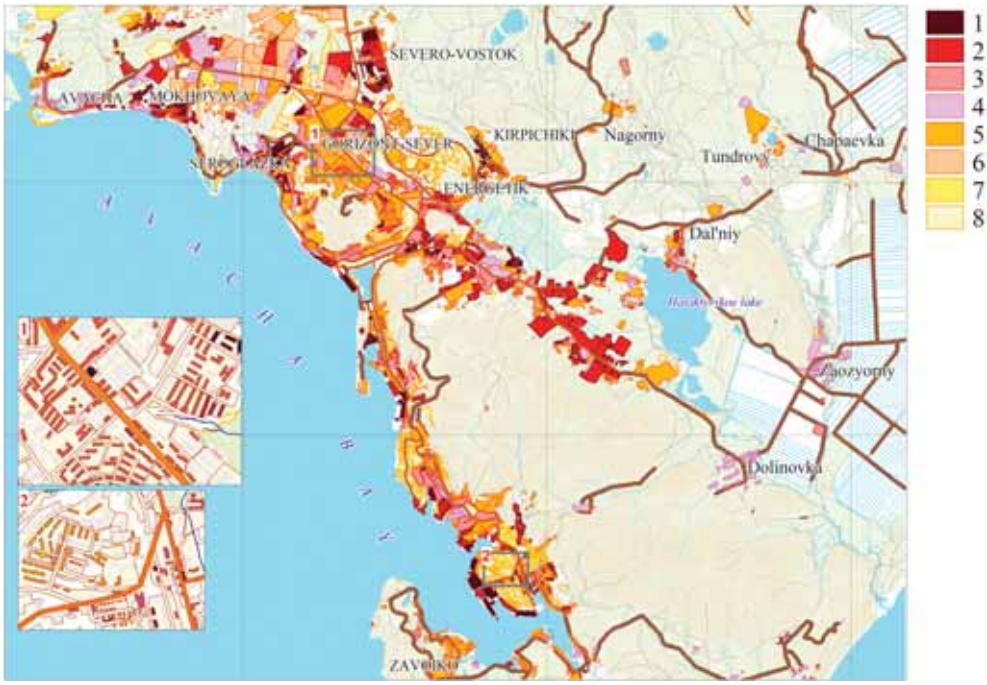

Fig. 19. Individual seismic risk R_s zonation for the Petropavlovsk-Kamchatsky City for a scenario event in zone AVS; values of risk for city districts:

1 – < 2 · 10^{-3}; 2 – 5 · 10^{-4} ÷ 2 · 10^{-3}; 3 – 2 · 10^{-4} ÷ 5 · 10^{-4}; 4 – 1 · 10^{-4} ÷ 2 · 10^{-4}; 5 – 5 · 10^{-5} ÷ 1 · 10^{-4}; 6 – 1 · 10^{-5} ÷ 5 · 10^{-5}; 7 – 5 · 10^{-6} ÷ 1 · 10^{-5}; 8 – > 5 · 10^{-6}

(Table 12, Fig. 19). Using possible source zones as input data on seismic hazard level, as well taking into account the influence of ground conditions, allows to get more detailed differentiation of risk values at urban level.

Taking into account the fact that maximum values of risk for Petropavlovsk-Kamchatsky City are related to earthquakes in zone AVS and maximum expected losses are typical of a scenario event in zone PET, which is characterized by low risk values, the following conclusions were drawn that programs, plans and preventive measures aimed at risk reduction should be developed and implemented in two stages. For long term planning maximum expected losses should be taken into account: expected fatalities = 15,000 persons; injuries = 33,000 persons. For short term planning the measures should be implemented which take into account expected losses: fatalities = 2,600 persons; injuries = 8,000 persons.

CONCLUSIONS

In the paper the influence of input data about seismic hazard on ambiguity of seismic risk assessment at different levels has been shown. The practice of crisis management shows that the reliability of risk or loss computations strongly depends on many factors [Bonnin & Frolova 2010; Frolova et al. 2011]. Among them, the main factors are the following: uncertainty on mathematical models used for simulation shaking intensity, behavior of building, population and other elements at risk; completeness and reliability of databases on elements at risk (population and built environment) and hazard sources; reliability of regional shaking intensity attenuation relationships; reliability of regional vulnerability functions for different elements at risk caused by earthquakes and other secondary natural and technological hazards; uncertainties on rapid determinations of event parameters by seismological surveys; lack of access to confidential sources of information.

On the whole, uncertainties on the parameters used in seismic risk estimation process are numerous and large. Taking into account the present situation the expert participation in earthquake risk estimation is very vital. Visualization of seismic risk and vulnerability assessment on the maps of different details facilitate expert estimation of the obtained results and their acceptability. ■

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LE TOURISME INDUSTRIEL EN ALLEMAGNE: ÉTATS DES LIEUX, POINT FAIBLES ET DÉFIS[1]

INDUSTRIAL TOURISM IN GERMANY: SITUATION, WEAKNESSES AND CHALLENGES

RÉSUMÉ. Le tourisme industriel, c'est-à-dire la visite de sites industriels tant actuels qu'abandonnés (ou de ce qu'il en reste), constitue depuis des années un secteur de l'économie touristique en augmentation constante, même s'il ne perdra sans doute jamais son caractère de "niche"... La plupart des offres de ce secteur se fait dans le cadre général du tourisme culturel, compris comme vacances dites "actives" ou "à sensations" (parfois a[1]ssociées à des objectifs pédagogiques), par nette opposition à l'aspect repos et détente des vacances plus classiques. Les formes de l'offre et de la demande qui se sont développées dans le tourisme industriel ont désormais pris une importance croissante non seulement pour les régions industrielles dites "historiques", mais aussi pour celles encore en activité aujourd'hui, car de tels flux touristiques peuvent avoir des effets très positifs en matière de politique structurelle, d'économie régionale et de réputation.

Tout récemment, on a assisté au développement de remarquables destinations touristiques dites "industrielles" (Brand Worlds ou parcs/musées à thème liés à l'industrie) tant dans les vieux pays industrialisés d'Europe et d'Amérique du Nord que dans les nouveaux pays industrialisés, par exemple en Asie. Nombre d'entre eux n'ont pas à craindre la comparaison avec l'attirance exercée par les sites classiques du tourisme national et même international.

Après un aperçu de l'état actuel des schémas de l'offre et de la demande dans le tourisme industriel en Allemagne, l'analyse portera sur les points suivants:

– le passage sous silence des aspects controversés et sombres de l'industrialisation (notamment concernant les périodes de guerre, d'annexion et d'occupation)

– les innovations (notamment sous la forme de Brand Worlds, par exemple dans l'industrie automobile).

MOTS-CLES: le tourisme culturel, les régions industrielles « historiques », flux touristiques, parcs/musées thèmatiques, patrimoine culturel mondial

ABSTRACT. Industrial tourism, i.e. visiting both active and historic industrial plants (or their historical remains), has been a

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growing sector in tourism for years, but is nevertheless unlikely to lose its "niche" character... Today it is generally offered under the general heading of cultural tourism, and in this context is often also marketed as active or adventurous tourism (and associated with educational aims), both in marked contrast to the traditional relaxing holiday. The forms of supply and demand that have developed in industrial tourism are of growing significance both for historic and active industrial regions, as such tourism can provide very positive stimuli for structural policy, regional economies and reputations.

Recently, remarkable industrial tourism destinations (industrial Brand Worlds) have emerged both in the old industrialised countries of Europe and North America and in *Newly Industrialising Countries*/NICs, e.g. in Asia. Many of these destinations need not fear comparison with the attractiveness of classical destinations for national or even international tourism, and a few leading industrial sites already have impressive visitor numbers.

After a brief overview of the current state of supply and demand in industrial tourism in Germany, the following points will form the focus of the analysis:

– Suppression of controversial and dark aspects of industrialisation (especially in times of war, annexation and occupation)

– Innovations (particularly in the form of so-called Brand Worlds, e.g. in the automobile industry).

KEY WORDS: cultural tourism, historic and active industrial regions, tourist flows, thematic parks/museums, world cultural heritage

INTRODUCTION

La notion et le fait du"tourisme"sont pluridisciplinaire. Son intérêt, tant conceptuel qu'empirique et économique, est grand du point de vue de nombreuses disciplines scientifiques, mais aussi compte-tenu d'orientations pratiques très différentes [pour s'en convaincre, il suffit de jeter un regard sur les tableaux spécifiques comme p.e. celui brossé par Becker, Hopfinger, Steinecke [2004]. Les approches scientifiques des problématiques liées aux loisirs et au tourisme s'opèrent donc avec des objectifs très variés; d'importantes difficultés en résultent lorsqu'il s'agit d'élaborer des définitions et des procédés qui fassent l'unanimité. La géographie du tourisme se focalise sur le rapport entre l'espace et les formes les plus diverses du déplacement; il s'agit donc des *donnés de base*(paysages naturels et culturels p.e.), des *activités* (mobilité des voyageurs et développement infrastructurel p.e.) et des *effets* (changements dans l'environnement et sur le marché du travail p.e.). Dans les cas extrêmes, nous avons pu assister à la création de paysages profondément marqués, voire même créés de toutes pièces par le tourisme [cf. entre autres Shaw, Williams 2004].

Certes, des éléments de paysages tels que des sites industriels ou des bâtiments et infrastructures (comme des ponts, des canaux ou des cités ouvrières) érigés dans le cadre d'une activité industrielle, ont retenu, depuis le début de l'industrialisation, l'attention même de visiteurs qu'aucun intêrêt professionnel ne reliait à ces objets. Ces sites, très souvent considérés comme des "miracles de la technique", ont été très tôt intégrés aux activités quotidiennes et récréatives par ce genre de visites et de voyages.

Pendant longtemps, ces formes d'excursions et de voyages ainsi que l'offre et la demande qui les caractérisent n'ont pas retenu l'attention, qu'elle soit d'ordre scientifique ou pratique. Au contraire, elles ont été souvent vues en contradiction par rapport à ce qui était perçu comme les déclencheurs spécifiques des différentes formes de tourisme; en effet, la majorité des gens se met de toute évidence en route pour chercher le repos, le changement et l'inspiration

dans des paysages naturels et culturels "beaux", "typiques"ou "spectaculaires". Les sites industriels, et encore plus les paysages industriels, étaient au contraire synonymes de bruit, de saleté et de maladie (ce qui était d'ailleurs souvent le cas), donc d'un monde diamétralement opposé à ce que l'on espérait trouver durant son temps libre ou ses vacances. "Industrie" et "tourisme" étaient incapables de faire bon ménage, il était donc hors de question de "concevoir" les paysages industriels comme destinations touristiques.

Pourtant, ces paysages industriels ont été créés, cultivés par l'homme et sont donc objets de recherche de la géographie humaine(en allemand "Kulturgeographie"). Mais le concept de "paysage cultivé" a été compris, dans une large mesure, comme synonyme d'espace rural indemne des conséquences de l'industrialisation [cf. à ce sujet l'importance et l'essor pris, en Allemagne surtout, par la 'conservation des paysages cultivés", en allemand "Kulturlandschaftspflege", Schenk, Fehn, Denecke, 1997]. Le terme de "paysage cultivé industriel"s'est longtemps heurté à l'incompréhension et reste encore inusité, même en géographie. Ce terme (en allemand"industrielle Kulturlandschaft") que l'on peut lire sur un panneau d'information à l'entrée principale de l'ancienne mine de charbon Zollverein XII, Patrimoine mondial de l'UNESCO depuis 2001, est une exception digne d'être relevée.

La convergence d'évolutions très différentes mais pourtant liées les unes des autres a mené dans le dernier tiers du 20ème siècle à un net changement des pratiques et des points de vue traditionnels, et la preuve la plus nette en est le néologisme allemand mariant l'industrie à la culture: "Industriekultur"(cf. ci-dessous). *Premièrement*, la dichotomie longtemps de mise entre culture élevée et culture quotidienne a commencé à s'estomper [à propos des conséquences pour la géographie du tourisme, cf. Steinecke 2007], *deuxièmement* l'approche de l'archéologie industrielle, développée en Angleterre, a trouvé un écho sur le continent et *troisièmement*, les pertes d'objet et de genres de vie liées à la désindustrialisation accélérée des années 1960 et 1970 ont mené à une reconsidération de l'héritage industriel et à une importance croissante du tourisme industriel.

Aujourd'hui, c'est surtout dans deux domaines que l'on voit aujourd'hui d'importants potentiels touristiques industriels: d'une part dans les différents types et éléments d'anciennes installations industrielles, d'autre part dans des sites de production encore en activité. Parmi ces derniers, on remarque tout particulièrement les parcs à thèmes liés à l'industrie/parcs de marque(s), auxquels il faut aussi ajouter quelques musées d'entreprises très sophistiqués. Ils constituent non seulement de nouvelles balises dans nos paysages industriels et touristiques, mais reflètent aussi le monde industriel par un réalisme tout à fait innovateur. S'y ajoutent d'autres sites, par exemple des lieux classiques d'archivage, de collection et de mémoire dans la mesure où ils ont un rapport avec la technique en général ou avec le secteur productif en particulier.

On peut regrouper aujourd'hui toutes les facettes matérielles et immatérielles liées à ces mondes industriels, historiques et contemporains sous le terme de "culture industrielle", qui inclut aussi la réalité et le terme plus restreints de"patrimoine industriel".

Nombre de ces sites sont devenus des destinations touristiques, c'est-à-dire d'un tourisme industriel. Par conséquent, ils sont des objets de curiosité pour notre sous-discipline "géographie du tourisme".

Une première définition du terme tourisme industriel datant de 1986 reste aujourd'hui largement valable, même si l'on trouve dans la littérature internationale des versions modifiées en fonction d'objectifs particuliers:

"...de telles formes de mobilité spatiale, déclenchées par la force d'attraction exercée sur des visiteurs extérieurs par des systèmes et des paysages industriels en activité ou désaffectés ..."

[Soyez 1986, p. 109, traduit de l'allemand du texte original; cf. plus récemment Fontanari, Weid 1999, Gelhar 2005, Otgaar 2010].

Dans le bref aperçu qui suit seront abordés de manière compacte les thèmes et problématiques annoncés dans le titre.

ÉVOLUTION ET ÉTAT DES APPROCHES DE LA CULTURE ET DU TOURISME INDUSTRIELS

A l'opposé de la situation encore observée dans les années 1980 et 1990, la culture industrielle et le tourisme industriel font aujourd'hui l'objet d'une large reconnaissance [pour les détails cf. Soyez 2013a, p. 361–364]. Même s'ils se situent encore plutôt en marge à la fois dans l'économie touristique et dans la perception du grand public, ils se sont établis dernièrement en tant que facettes importantes du secteur culturel et des branches du tourisme culturel [cf. Steinecke 2007].

En Allemagne, ce développement a pris de la vitesse, à quelques exceptions près, avec l'exposition internationale d'architecture et d'urbanisme IBA Emscherpark de 1989 à 1999. C'est une initiative de grande envergure visant la restructuration d'anciennes zones industrielles à l'abandon dans le Bassin de la Ruhr (voir ci-dessous).

Si l'on compare la situation actuelle avec celle d'il y a une génération, on constate qu'un pas de géant a été franchi. Et ce tant dans le discours public que dans les mises en valeur dans les catégories les plus diverses d'exploitation et de protection, et allant au-delà du site classique d'un monument protégé. Il faut nommer ici:

- des sites industriels d'une certaine dimension, tels que les sites de Rammelsberg/Goslar et Völklinger Hütte/Völklingen inscrits par l'UNESCO au Patrimoine culturel mondial [Cybergeo: http://www.rammelsberg.de/index.php?s=41 & m = 1 & l = fr; http://www.voelklinger-huette.org/de/weltkulturerbe-voelklinger-huette/]

- des pans de l'ancien paysage industriel [par exemple le complexe industriel de la mine de charbon de Zollverein, également inscrit au Patrimoine culturel mondial, Cybergeo: http://www.zollverein.de/service/ english-page]

- des musées de l'industrie décentralisés; ils offrent de nombreux sites ainsi que des circuits, des routes à thème et des réseaux reliant les destinations du tourisme industriel [Rheinisches Industriemuseum, Westfälisches Industriemuseum, WasserEisenLand Märkische Industriekultur, Route de la culture industrielle dans la Ruhr, ERIH/Route Européenne du Patrimoine Industriel, Cybergeo: http://www.industriemuseum.lvr.de/de/startseite.html; http://www.lwl.org/LWL/Kultur/wim/portal/profil/ englisch]; http://www.wassereisenland.de/Ueber-uns/Unsere-Region-Suedwestfalen; http://www.route-industriekultur.de/route-industriekultur.html; http://www.erih.net/fr/bienvenue.html)

- des "musées productifs", c'est-à-dire certes de vrais musées, mais où la production continue pour les visiteurs, comme la Fabrique de chocolat Imhoff à Cologne ou la Forge à matrice Hendrichs à Solingen [Cybergeo: http://www.schokoladenmuseum.de/start.html; http://www.industriemuseum.lvr.de/de/solingen/solingen_1.html]

- des parcs à thème liés à l'industrie ou à une marque, tels que le parc Volkswagen Autostadt, le parc voestalpine stahlwelt, le parc Swarowski Kristallwelten [Cybergeo: http://www.autostadt.de/en/start/; http://www.voestalpine.com/stahlwelt; http://kristallwelten.swarovski.com/Content.Node/Startseite.en.html]

Toutes ces réalisations permettent certes, dans les catégories de protection privées, institutionnelles et légales les plus diverses, de préserver et de rendre accessibles de nombreux témoins de différentes époques industrielles – et aussi de différents modes de production.

De toutes les catégories de mise en valeur ayant trait au monde industriel pourtant, les

parcs à thème et musées liés à l'industrie ne sont pas seulement ceux qui disposent du plus grand pouvoir d'attraction.

De plus en plus, ces parcs révèlent également des facettes évidentes d'un tourisme de masse clairement en pleine expansion dans cette niche aussi (concernant par exemple le nombre de visiteurs, l'intensité du marketing et de la médiatisation, le volume d'investissement, les formes d'organisation, la densité de la mise en scène, le rayonnement spatial etc.) [pour les détails cf. Steinecke 2000, 2007, Hinterhuber, Pechlaner, Matzler 2001, Eckardt 2005].

Les interactions et les types de tourisme industriel peuvent, comme c'est souvent le cas concernant des thèmes et des domaines plus traditionnels de la géographie du tourisme, être analysés tant du point de vue de l'offre et de la demande qu'au regard des processus et des acteurs, une approche qui ne peut pas être approfondie ici. En revanche seront présentés dans ce qui suit quelques idées conceptuelles et des déficits sensibles.

Réflexions d'ordre conceptionnel

En se basant sur un diagramme de Steinecke [2001, p. 90], on peut aborder plusieurs types de catégories de la représentation des mondes industriels qui caractérisent aujourd'hui nos paysages culturels (cf. Fig. 1):

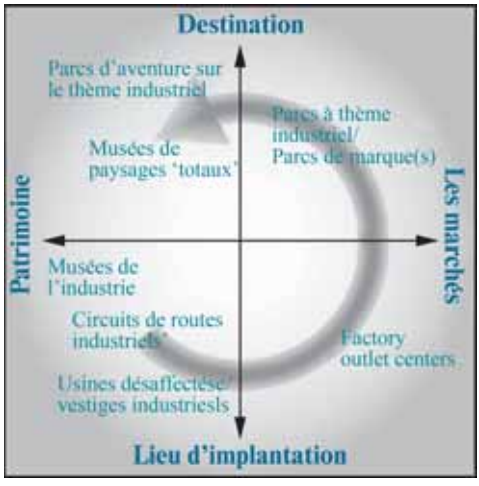

Fig. 1: Les "mondes de l'industrie" dans nos paysages culturels: essai de synopse dans un espace des attributs bi-dimensionnel

[Source: modifié d'après Soyez, Li 2006, Steinecke 2001. Conception D. Soyez, réalisation R. Spohner, Institut de Géographie, Université de Cologne]

Le diagramme permet de positionner les différents types de mise en valeur les uns par rapport aux autres et sert de synopse de tous les éléments cités jusqu'ici (et d'autres) dans ce domaine: il ne montre pas seulement de quelle manière toute une variété de "représentations des mondes industriels" marque nos paysages; il en ressort aussi quelles sont les formes spécifiques de mise en valeur pour le tourisme industriel. La flèche retrace la succession temporelle des différentes approches depuis plusieurs décennies.

Une conceptualisation et une analyse géographiques plus poussées des diverses représentations du monde industriel nécessiteraient d'abord des études approfondies des aspects suivants et de leurs interdépendances:

- Les approches de documentation et d'interprétation du patrimoine historique industriel
- Les types de visites et déroulements temporels ainsi que d'explications des installations industrielles y compris leur environnement fonctionnel
- Les genres et particularités de l'autopromotion des entreprises
- L'explication et la documentation de l'évolution des paysages allant de "proche de l'état naturel" à "paysages industriels en cours de désagrégation"...

Ces approches rapidement esquissées peuvent certes paraître satisfaisantes d'un point de vue traditionnel de la géographie du tourisme. Si l'on se place dans une autre perspective, jusqu'à présent rarement choisie, on s'aperçoit cependant que presque toutes les approches concernant la culture industrielle et le tourisme industriel mises en œuvres jusqu'ici présentent des déficits marqués [pour plus d'informations cf. Soyez 2013a, p. 265 & 2013b].

Ils concernent d'une part le caractère de transnationalité des connexités industrielles, de ces facettes de la réalité donc qui ne peuvent être compréhensibles si l'on ne prend pas en considération les processus transfrontaliers; d'autre part les souvenirs douloureux, mêmes traumatisants, liés à de nombreux lieux et événements, aussi et surtout dans les sites industriels, dans une société et ses constructions mémorielles. Les deux, transnationalité et traumatisme, peuvent aussi être étroitement liés, et les deux peuvent conduire à des processus de patrimonialisation, dans la mesure où le souvenir n'est pas refoulé, mais volontairement entretenu.

Ce sont de tels terrains problématiques qui feront l'objet principal du prochain chapitre.

TRANSNATIONALITÉ ET TRAUMATISMES

Points de départs

La transnationalité, c'est-à-dire le résultat de flux transfrontaliers de biens, personnes et idées, est un élément constitutif de presque tous les processus de changements socio-culturels. Particulièrement lorsqu'il s'agit d'innovations, on perçoit des modèles, et dès que l'on peut supposer que les copier apporte un avantage, quel qu'il soit, se mettent alors en place des processus d'imitation ou d'adoption complète. Étant donné que les processus modernes d'industrialisation commencent seulement à l'époque des États nationaux, nombre des processus d'adoption constatés ici sont le résultat du franchissement des frontières nationales: les mutations industrielles sont donc marquées en grande partie par une transnationalité inhérente [concernant la terminologie cf. Jackson, Crang & Dwyer 2004].

Par conséquent, une compréhension plus approfondie du monde industriel n'est pratiquement pas envisageable sans une appréciation des impulsions transfrontalières de l'extérieur et/ou vers l'extérieur. C'est pourquoi toute représentation des mondes et des époques industriels, et par là toute interprétation touristique dans ce domaine, devrait rendre lisibles les facettes les plus importantes de leur transnationalité.

De tels processus peuvent se produire aussi en relation avec des événements qui ont eu un effet traumatisant tant sur les individus que sur des sociétés entières. Ils peuvent rester très douloureux pendant des générations et ainsi conserver un énorme impact (guerre, violence, perte...).

Transnationalité et traumatismes, de même que leurs causes et implications pour des lieux concrets ou des sociétés entières, font depuis longtemps partie des thèmes traités par de nombreuses disciplines, et il en est de même pour la géographie du patrimoine, sous-discipline qui est en train de se former lentement. Le concept de l'"héritage dissonant" est ici particulièrement important, comme c'est presque toujours le cas lorsque des événements difficiles ou même traumatisants sont liés à des lieux précis et commémorés de manières très contraires par les différentes parties, notamment dans des contextes transfrontaliers et multiculturels [concernant les conceptions et les résultats empiriques, cf. entre autres Tunbridge, Ashworth 1996, Graham, Ashworth, Tunbridge 2000, Ashworth, Graham, Tunbridge 2007) et dans la geographie du tourisme [cf. Lennon, Foley 2000, Ashworth, Hartmann 2005, Quack, Steinecke 2012, Hartmann 2013].

Si l'on reporte cependant le regard vers les thèmes, ici au centre de nos développements, de la culture industrielle et du tourisme industriel, ainsi que vers les stratégies de mise en valeur et d'interprétation qui y prédominent, on s'aperçoit que jusqu'ici aussi bien la transnationalité que les traumatismes, et par là les différentes cultures du souvenir qui y sont rattachées, restent en grande partie non traitées, voire même refoulés [à l'opposé des nombreuses discussions intéressantes en Histoire et Sciences Humaines et Sociales, par exemple François 2006; cf. entre autres Soyez 2009, 2013, Lauterbach 2012].

À quelques exceptions près, la majorité des approches et des réalisations dans les domaines de la culture et du tourisme industriel, et sur les plans nationaux et internationaux, est donc caractérisée par

- une obstination à penser dans des catégories nationales et

- un héritage "expurgé", c'est-à-dire une exclusion parfois fortuite, mais en fait souvent systématique, des heures sombres, douloureuses, effroyables de l'histoire de l'industrialisation.

Pour commencer, la Ruhr en offre de bons exemples de démonstration dans ces domaines déficitaires.

L'évolution dans le Bassin de la Ruhr

L'exposition internationale IBA Emscher Park, réalisée entre 1989 et 1999, constitue un projet extraordinairement ambitieux visant à restructurer, grâce à des centaines de projets, une grande région anciennement industrialisée. L'objectif principal était de "réparer" d'une part le paysage naturel en grande partie asservi et radicalement modifié par une industrialisation sans égard et d'autre part les dérives très problématiques en matière d'urbanisme et de développement social, qui s'étaient trouvées encore renforcées par la désindustrialisation naissante à partir de la fin des années 1950 [cf. Kilper, Wood 1995, Danielzyk, Wood 2000, Prossek et al. 2009, RVR 2012).

L'un des plus importants projets partiels de l'exposition IBA Emscher Park était la "route de la culture industrielle" [en allemand: Route der Industriekultur, cf. Kift 2008]. Elle a révélé des possibilités de conserver et de valoriser d'importants témoins des 150 ans d'histoire de l'industrialisation de la Ruhr et de les utiliser de différentes manières – comme musée, coulisse, objet réutilisé autrement. On distingue: les Ankerpunkte, sorte de sites icônes, les cités ouvrières, les panoramas, les terrils, les routes à thème et, finalement, les centres de visiteurs où des vues d'ensembles sont concentrées, tous devenus des destinations d'un tourisme industriel remarquable qui a également contribué à améliorer considérablement l'image de marque de la Ruhr (interne et externe), auparavant perçue comme sale et complètement dépourvue d'intérêt touristique.

C'est l'ancienne mine de charbon "Zollverein XII" à Essen qui est au centre de cette réalisation, unique au monde dans son approche, ses objectifs et sa cohérence (cf. Fig. 2). Désaffectée en 1986, elle a été inscrite en 2001 sur la liste du Patrimoine culturel mondial et est devenue l'une des principales destinations touristiques de la Ruhr (avec un nombre annuel de visiteurs estimé à plus d'un million).

Si l'on considère la route de la culture industrielle dans son ensemble, elle est certes très impressionnante. Elle ne reflète cependant qu'un choix très sélectif: sont principalement représentées les mines de charbon, la métallurgie et la sidérurgie

Fig. 2. Entrée centrale et chevalement principale de l'ancienne mine de charbon «Zollverein XII» à Essen, inscrite en 2001 sur la liste du Patrimoine culturel mondial de l'UNESCO (Photo avec l'aimable autorisation de Xue Desheng)

[quant à d'autres points critiques cf. aussi Heinemann 2003, Soyez, Li 2009].

Mais il y a deux faits constitutifs de toute industrialisation qui manquent encore totalement même dans ces réalisations remarquables de la Ruhr: des informations sur les facettes transnationales et sur les phases sombres extrêmement douloureuses de l'histoire récente.

Cette situation ne résulte pas d'un éventuel manque d'informations, car l'implication de nombreuses entreprises dans les chapitres sombres de l'histoire allemande récente a été étudiée par les historiens (mais à peine par les géographes...) jusque dans les moindres détails. Parmi de nombreux exemples nous ne citerons ici que la problématique du travail forcé effectué par des Polonais, des Russes et des Français, entre autres nationalités, dans les mines et l'industrie métallurgique et sidérurgique de la Ruhr [cf. entre autres Urban 2002, 2014, Kuhn, Weiß 2003, Tenfelde, Seidel 2005].

Au vu de ces omissions frappantes les entreprises allemandes du secteur automobile sont particulièrement intéressantes. Premièrement, elles font presque toutes partie du nombre restreint d'entreprises allemandes qui ont fait étudier (bien que tard) leur histoire sous le Troisième Reich par des historiens indépendants. Deuxièmement, avec leurs parcs à thèmes/musées liés à l'industrie elles doivent être comptées, comme souligné dans l'introduction, parmi les "nouveaux venus" dans le domaine de la culture industrielle, tout aussi surprenants que tout à fait bienvenus. Elles sont également devenues les gardiens les plus professionnels de l'héritage matériel et immatériel de l'industrie automobile, héritage à peine représenté à sa juste mesure jusqu'à la fin du XXème siècle (les nombreuses collections de voitures anciennes, qui ont toujours existé, ne suffiront jamais à remplir une telle fonction). Troisièmement, et il y a là un autre domaine déficitaire, certaines de ces entreprises ont une histoire étonnante, et très particulière, en ce qui concerne l'aéronautique et la technologie spatiale, histoire qui fait jusqu'à présent presque entièrement défaut dans le domaine de la culture industrielle. Quelques aspects importants en rapport à ce sujet seront traités ci-dessous [pour plus de détails cf. Soyez 2013b].

Les parcs à thème liés à l'industrie

Comme précédemment indiqué, les parcs à thème dédiés à l'industrie doivent être considérés comme des points culminants impressionnants, voire spectaculaires, des représentations industrielles dans nos mondes actuels. L'Autostadt Volkswagen (Wolfsburg), le Mercedes-Benz Welt (Stuttgart; cf. Fig. 3), le BMW World (Munich)

Fig. 3. Le "Mercedes-Benz Museum"à Stuttgart-Untertürkheim comme exemple d'un parc à thème/musée lié à l'industrie (Source: photo prise par l'auteur)

et l'Audi Forum (Ingolstadt) en offrent d'excellents exemples.

Ici, rien du monde industriel ne semble manquer. Sont expliqués et illustrés de manière impressionnante et compréhensible pour toutes les générations de visiteurs:

- l'histoire, l'évolution technique, la palette de produits (dans les musées les collections historiques, et dans les centres de livraison et les centres de vente la collection actuellement disponible)

- l'étroite relation spatio-fonctionnelle avec la production actuelle (possibilités de visites d'usine), tout cela complété par des expositions permanentes et temporaires, des manifestations en tous genres, des activités et des informations adaptées aux intérêts des différents groupes, allant des passionnés de technique aux enfants de maternelle.

Les objectifs des entreprises sont la représentation professionnelle de la marque, la vente de voitures et la fidélisation des clients. Mais: la réalité industrielle est ainsi rendue transparente, du moins à ce qu'il y paraît, ce que pratiquement aucune autre destination du tourisme industriel ne peut offrir.

Et pourtant, ces sites sont aussi les exemples les plus frappants des déficits qui ont été exposés à l'instant. Car ils excluent sciemment une des périodes les plus douloureuses, même traumatiques de notre histoire – et de celle de beaucoup d'autres nations européennes: Volkswagen a été pendant longtemps l'entreprise qui a coordonné le système de production du missile V1 (le prototype des actuels missiles de croisière); la production a d'abord été concentrée à KdF-Stadt (Kraft-durch-Freude-Stadt) près de Fallersleben, après la guerre rebaptisé Wolfsburg, puis le système de production avec ses nombreux sous-traitants a été étendu et réparti sur une grande partie des territoires allemands occupés ou annexés [cf. la documentation de Mommsen, Grieger 1996].

Mercedes-Benz (à l'époque Daimler-Benz), quant à elle, a apporté son concours technique lors d'une phase décisive de l'élaboration du missile V2 et livré des éléments-clé (ce missile fut la première fusée balistique du monde et a marqué le début de la technique aérospatiale) [cf. Hamburger Stiftung für Sozialgeschichte des 20. Jahrhunderts 1987, Hopmann et al. 1994, Wagner 2001].

Que les choses soient bien claires: l'intention n'est ni de noircir ces deux entreprises, ni de souligner l'état d'avancée de l'industrie allemande à cette époque. Ce qui importe est tout simplement d'établir un fait historique et la nécessité d'intégrer ces aspects dans la thématique traitée ici.

Les deux armes à distance V1 et V2 étaient le produit final de deux systèmes de production industrielle extrêmement spécialisés, et donc – entreprises, sites et réseaux de production compris – potentiellement intéressants pour la culture et le tourisme industriels (secteur de la technique aérospatiale).

Ces connexions sont très bien établies au niveau historique, mais largement oubliées, refoulées ou même sciemment tues au grand public – ainsi que dans les domaines de la culture industrielle et du tourisme industriel. C'est d'autant plus vrai si l'on les relie à l'une des périodes les plus effroyables de notre histoire: l'Holocauste.

On a pour habitude d'associer le Troisième Reich en premier lieu avec les camps d'extermination. Mais on oublie trop souvent que presque toutes les formes de production en relation avec la guerre étaient intégrées dans le système concentrationnaire du Troisième Reich. A quelques exceptions près, la production industrielle allemande (de même que l'agriculture) ne pouvait fonctionner que grâce aux travailleurs forcés des camps de concentration et aux prisonniers de guerre. Ils étaient répartis dans tous les territoires occupés et annexés, dans d`innombrables de "commandos extérieurs", sortes de lieux satellites des camps les plus

connus du grand public. Certes, il s'agissait avant tout de camps dits de travail: soit ils étaient érigés à proximité des sites de production, soit au contraire c'étaient les sites de production qui étaient délocalisés à proximité des camps. Les conditions de vie dans ces commandos extérieurs n'étaient pas tellement différentes de celles dans les camps de concentration, les historiens allemands emploient ici un terme effroyable: l'extermination par le travail [cf. aussi le titre du livre de Riexinger, Ernst 2003, un document effrayant sur le système du camp de concentration Natzweiler-Struthof dans l'Alsace occupée et son commando extérieur de Kochendorf/Bade-Württemberg; cf. la carte synthèse p. 14/15 dans ce livre].

Et, pour revenir à la production des armes à distance V1 et V2: la plupart d'entre elles étaient produites, sous le contrôle de la SS, durant les derniers mois de la guerre, dans un site d'assemblage souterrain près de Nordhausen en Basse-Saxe, qui, lui, ne fonctionnait que grâce à des milliers de travailleurs forcés, beaucoup d'eux venus du tristement célèbre camp de concentration Buchenwald et "relocalisés" dans le camp de concentration Mittelbau-Dora [pour les détails cf. Mommsen, Grieger 1996, Wagner 2001].

Ainsi la production industrielle sous le Troisième Reich n'était pas "transnationale" seulement par ses emplacements et ses interpénétrations dans des grandes parties de l'Europe. Elle était transnationale aussi par l'exploitation en général inhumaine de travailleurs forcés originaires de plus de vingt pays européens.

Tandis que beaucoup d'autres chapitres douloureux de nos histoires sont aujourd'hui devenus des destinations du "tourisme sombre", les côtés les plus pénibles et dérangeants de l'histoire industrielle ne sont pas thématisés sur les sites de la culture industrielle. Ils n'ont donc pas fait naître de "tourisme industriel sombre" non plus.

L'attitude et le comportement des entreprises sont tout-à-fait compréhensibles: elles craignent pour leur réputation et leurs revenus. Mais une telle position, et le "nettoyage" ciblé de leur propre histoire qui en découle, sont cependant extrêmement regrettables. En fait ils sont également honteux, étant donné que les faits historiques sont établis depuis longtemps, parfois même, comme il l'a déjà été souligné, avec l'aide des entreprises elles-mêmes, comme c'est le cas pour Volkswagen et Mercedes-Benz. Et ces deux entreprises, comme tant d'autres, semblent sous-estimer complètement ce qu'une politique d'information plus ouverte même par rapport à leur passé sombre pourrait ajouter à leur réputation comme "responsible corporate citizen": leur passé pourrait représenter ce qui est considéré par de nombreux chercheurs comme une "resource in conflict" [cf. le titre du livre de Tunbridge, Ashworth 1996] même dans leurs parcs de marque.

CONCLUSION

Les conclusions seront brèves:

En ce qui concerne l'état du tourisme industriel en Allemagne, il est caractérisé par d'impressionnantes réalisations dans la représentation des mondes industriels et de grands progrès dans leur mise en valeur touristique, surtout aussi dans des secteurs industriels jusqu'il y a peu de temps complètement absents dans le domaine de la culture industrielle et patrimoniale.

On constate d'abord des faiblesses de deux points de vue:

D'une part, la plupart des sites (re)mis en valeur pour le tourisme industriel appartiennent au domaine minier, de la métallurgie et de la sidérurgie. Beaucoup d'autres branches sont fortement sous-représentées.

D'autre part, les réalisations les plus spectaculaires et les principales destinations du tourisme industriel témoignent surtout de la période dite de "haute industrialisation",

donc à partir du milieu du XIXe siècle; le début de l'industrialisation et les récentes évolutions, mis à part les parcs à thème de l'industrie automobile, sont fortement sous-représentées.

Les défis pour les travaux à venir résident principalement dans le fait que les processus de transnationalisation et les périodes sombres, voire même traumatiques, de l'industrialisation (pendant les périodes de paix et de guerre), ainsi que des approches correspondantes dans le domaine du tourisme industriel, sont des sujets peu abordés; il est urgent d'élaborer des représentations et des formes d'interprétation contemporaines, surtout concernant les sites évoquant des périodes plus douloureuses, qui, elles aussi, font partie de notre patrimoine, un patrimoine donc qui peut, et qui doit, être partagé.

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HEALTH OF URBAN POPULATION IN MOSCOW AND BEIJING AGGLOMERATIONS

ABSTRACT. The paper presents the results obtained under the joint Russian-Chinese RFBR project № 12-05-91175-ГФЕН_а aimed at assessment of the state of the environment and health of the population in urban areas in Russia and China. The paper presents the authors' approach to a comprehensive evaluation of the impact of the environment on the population health of urban agglomerations and a method of regional medico-geographical analysis. A series of analytical and synthetic maps was compiled and used for a comparative geographical analysis of medical and environmental situation in Moscow and Beijing – major metropolitan areas with different natural and socio-economic conditions. The paper discusses the influence of the environment on the state of public health and identifies the leading risk factors, both general and specific to each region.

KEY WORDS: urban agglomeration, Moscow, Beijing, public health, medico-geographical analysis

INTRODUCTION

Problems of the influence of the urban environment on public health has been a subject of interest for researchers since the early 1960s, when it became clear that a rapid change in the environment associated with the growth of cities and various social aspects have a very strong influence on human life [Environment ..., 1979]. Urban ecosystems have a number of unique features. In large cities, climatic, geophysical, and land conditions are transformed and gravity, magnetic, thermal, and electric fields of the Earth are modified. The environmental quality of cities affects life expectancy and health of the population, their physical and social activity, and demographic behavior [Malkhazova, Koroleva, 2011].

Benefits of urban forms of settlement are of mainly economic and social nature. Cities have developed production and social structure, health systems, communications, provide a high level of comfort, form a certain level of material and cultural values, and provide more opportunities for education and career choices. Large cities and capitals concentrate highly qualified specialists, including medical personnel and scientific and creative intelligentsia. Being the centers of gravity of human and material resources, cities create the most favorable conditions for life.

At the same time, the process of urbanization is associated with significant adverse environmental changes. Even remote regions are under the growing impact of urban areas. Risk factors for

health in the urban environment involve its various components; the main negative consequence of human-induced changes is the environmental pollution [Rushton, Elliott, 2003; Wang, Krafft, 2008; Revich, 2010; Medical and Demographic ... 2011; Boas et al., 2011; Identification ..., 2014 et al.].

This paper discusses the results obtained under the joint Russian-Chinese RFBR project № 12-05-91175-ГФЕН_а aimed at assessment of the state of the environment and health of the population in urban areas in Russia and China. The authors present their approach to the integrated assessment of environmental impacts on health of urban agglomerations and a method of regional medico-geographical analysis. A series of analytical and synthetic maps was compiled and used for comparative geographical analysis of medical and environmental situation in Moscow and Beijing – major metropolitan areas with different natural and socio-economic conditions. The authors have analyzed the influence of the environment on the level of public health and have identified the leading risk factors, both general and specific to each region.

MATERIALS AND METHODS

The present-day medico-geographical studies are based on mathematical and statistical methods and techniques of mathematical and cartographic modeling. The authors have analyzed the existing methods and approaches to medical and environmental site assessments and have developed a method of assessment of the health status of the urban population. The approach was tested in Moscow and in Russia as a whole [Malhazova et al. 2010, 2012; Malhazova, Shartova 2013].

This procedure consists of several research stages involving both assessment of health indicators and the environmental factors that directly or indirectly affect health and livelihoods of the population.

The *first phase* consists of preparatory work; specifically, the main factors that affect health and livelihoods of the population of selected regions are selected. The information used in the analysis is based on the parameters that most clearly identify the impact of the urban environment on the population health. The information is selected based on expert assessment and analysis of literature, including details of environmental epidemiological, sanitary, and other studies, government reports on the state of the environment, and regulations [Environmental health indicators ..., 2002; Recommendations WHO ..., 2005]. Determination of the analyzed demographic and health indicators is based on the 10th WHO revision of the modern international classification of diseases (ICD-10) [International statistical classification of ..., 2003], used for recording and reporting the incidence, causes of death, and medical aid appealability of the population in the outpatient and inpatient health care system worldwide. The main components of the population in the analysis are children under the age of 14, men and women separately, and the overall population. Research can be conducted in dynamic (data analysis for a period of at least three years) or static aspects (a one-year "snap-shot"). Special attention is given to social factors (unemployment, average wages, availability of health facilities, etc.) and anthropogenic load (condition of air, water, and soil) in analysis of the urban environment.

The *second phase* includes collection of statistical data on administrative units of the relevant health authorities and organizations that monitor the environment and of the Federal Service of State Statistics. Statistical data are collected for entire regions, for individual administrative units within the regions, and, if possible, for the administrative units within the analyzed cities. The information obtained is compiled into a thematic database of medical and environmental data. The database structure includes the following thematic blocks: demographic, morbidity of the population by class of diseases, incidence of socially relevant and environmentally-dependent diseases, environmental health, socio-economic indicators, and indicators of the health system.

These data are further compiled into a spatial database, i.e., (GIS), for the visualization of the

research results and creation of cartographic products. The database structure allows timely updates with new data for various administrative and territorial levels.

At the *third phase*, a mathematical-cartographic modeling of health and environmental situation of territories is conducted. All the data are subjected to pre-analysis evaluation and ranked based on the identification of the maximum and minimum values and of their scatter. Medico-demographic and environmental factors are mapped based on this ranking. A series of analytical maps and a complement series of graphs reflect the spatial and temporal distribution of various medico-demographic, socio-economic, and environmental characteristics and are used for further analysis of the current state of the environment and public health.

Mathematical-cartographic modeling with methods of cluster analysis (dendrogram technique and K-means) are used for more in-depth study of the urban environment impact factors on the health of the population. It allows identification of groups of administrative units that are similar in terms of various nozoforms morbidity. A 10-score assessment method is used for the final integrated assessment of the environmental health situation.

The results of this comprehensive assessment of the health status are rendered cartographically. The main methods are cartograms and diagrammatic representation, traditionally used for mapping of phenomena for which data are presented in the context of the administrative-territorial units. Ranking is based on the natural gradation interval method with manual adjustment of the number of classes and their boundaries.

Comparative analysis of the health and vital activity of the population of different areas is done at the final, *fourth, phase* of the medical and environmental analysis. This approach is called comparative-geographical method and is a traditional technique of medico-geographical research. Comparative geographical method is crucial in evaluations of different geographical processes and phenomena in relation to the state of health of the population in different regions. Many environmental factors and health indicators are measured and ranked in a clear quantitative form, which allows for a relative geographical comparison of these indicators and identification of regional specifics of study areas.

This approach utilized basic software applications: MS Excel, a specialized package for statistical data processing Statistica, a cartographic geoinformation system ArcGIS, and graphic editing tool Adobe Illustrator.

The algorithm's schematic representation is shown in Fig. 1.

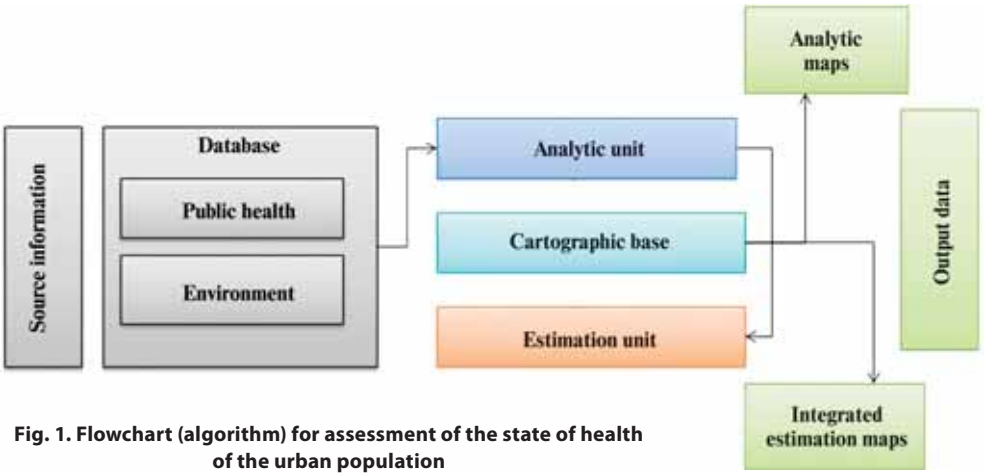


Fig. 1. Flowchart (algorithm) for assessment of the state of health of the urban population

Depending on the purpose of research, this technique can be used for:

– preliminary assessment of the environmental health situation;

– obtaining information about specific environmental and geographical components of the urban environment and public health;

– integrated assessment of urban health and environmental factors influencing its condition.

RESULTS AND DISCUSSION

The created databases were used for a comparative analysis of environmental factors affecting the health status and medico-geographical situation for the two metropolitan regions – Beijing (the Beijing area included rural areas) and the Moscow region (Moscow city itself and the Moscow region), in 2000–2012. The data presented below correspond to the official statistics of 2009–2010 and, partially, to 2011–2012.

The territory of the Beijing region is 16 808 km^2 (the urban area is 1 289 km^2); the territory of the Moscow region – is 44 379 km^2 (the urban area is 2 511 km^2). The Beijing region is composed of a plain terrain (40 %) and mountainous areas (60 %) (elevation of up to 2303 m.). The Moscow region is situated entirely on the East European Plain, with altitude difference of not more than 150 m.

The population of Beijing is about 21 million people; population density is 1 289 pop./km^2. The population of the Moscow urban area is 12.1 million; population density is 4 823 pop./km^2. Population size and density of the Moscow region is much smaller, i.e., 7.1 million people and 160 pop./km^2, respectively.

Analysis of the environmental components that may have a potential impact on the health status of the two urban regions, i.e., Moscow and Beijing, allows reaching the following conclusions.

Significant natural factors influencing the health status of the Beijing metropolitan area are associated with ***climatic conditions***. The region has hot summers and cold winters (November to March). In spring (April and May), there are often strong winds causing sand and dust storms. Extreme weather conditions are also present. Thus, in the summer of 2010, daily temperatures were +38 °C–+42 °C for 22 consecutive days. The average annual rainfall is 585 mm, including over 700 mm in the northern

Fig. 2. Smog in Beijing (photo by D. Orlov)

and western foothills and 450–600 mm in the southern part of the plains. About 85 % of the precipitation falls during the wet season from June to September. In addition, there is a high degree of rainfall inter-annual variability. The minimum (272 mm) was recorded in 1869 and the maximum (1406 mm) – in 1959. These weather conditions favor the concentration of pollutants in the atmosphere and the formation of smog in the territory of Beijing (Fig. 2).

The climate of the Moscow region is moderately continental with distinct transitional seasons; it forms a very favorable environment for human health and vital activities. Currently, however, climatic changes associated with global processes are being observed. Thus, over the past decade, the average annual air temperature rose 1.5 °C compared to the multi-annual average temperature (in January, it increased by 4 °C and by 1–1.5 °C in July); besides, there has been observed increased frequency of extreme climatic events. However, in general, we can note a less pronounced effect of climatic factors on the formation of the medico- geographical situation in the Moscow region, compared with Beijing.

Another important factor for the formation of a medico- geographical situation is the shortage of water availability in Beijing. The average volume of water is 3.77 billion m^3, of which the surface water is 2.04 billion m^3 and groundwater is 1.73 billion m^3. Water availability per capita is less than 300 m^3 per year, which is significantly less than the international standard of water supply (1000 m^3 per capita per year) for the country.

In total, there are 85 water reservoirs in Beijing with a total volume of 9.35 billion m^3, and 50 000 groundwater wells. The capacity of water supply is 0.6 million m^3 per day. About 90 % of wastewater is treated directly in the city center. In general, this region has the excessive use of both surface water and groundwater. Much of the time, most of the rivers are dry; conditions of river ecosystems are deteriorating. There is a high degree of water pollution: about 50 % of river water belongs to the class 3 quality. At the same time, there is a low level of treated wastewater (76 % in 2009).

In the Moscow region, there are more than 900 rivers and 1000 streams, a large number of lakes, and 13 main-maid reservoirs. The total volume of the reservoirs with volumes of more than 10 million m^3 is 1 270 million m^3. It should be emphasized that, for the Moscow region, the water availability factor is not a problem factor in respect to public health.

The priority socio-economic factor that has the greatest impact on the health status of the population in both regions is the intensive economic development and, as a consequence, the increasing urbanization accompanied by the growing anthropogenic load. Both regions have a long history of exploration and development; however, in the Moscow region, compared with Beijing, the transformations of recent years are less intense. Currently, 27 new free economic zones are reported in Beijing; there are more than 10 000 construction sites with the total area of 100 million m^2 annually. A characteristic feature of the transformation in Beijing is rapid change of the old city center.

Despite significant economic development of Beijing, continuous ***use of coal as fuel*** remains an important factor for the region affecting the health of the population. One of the areas of improvement of the medical and environmental situation in Beijing is the prevention and mitigation of particulate pollution, transformation of the energy system, and the transition to natural gas consumption.

The inevitable consequence of strong economic development of the regions is the high traffic load. A significant increase of the number of vehicles in recent years has caused air pollution. Thus, in 2010, in Beijing, there were 4.5 million cars (including 2 million privately owned). According to

estimates, the number of cars is increasing daily by more than 1 900. According to official data in 2011, the number of registered cars in Moscow was 4.1 million. Over the last two years, the number of registered motor vehicles more than doubled.

The main measures to prevent the further deterioration of the air quality include new licensing of trucks and motorcycles, standardization of fuel for local vehicles, and control of exhaust pollutants from vehicles. These activities are being currently implemented with varying degrees of intensity in both regions.

Another possible solution to this problem is the development of alternative modes of transportation, such as subways and electrical trains. According to the development plan of the Beijing metropolitan area, 16 new subway lines (stations), 6 light-rail lines, and 6 lines of suburban electrical trains will be built by 2020. Moscow plans to build more than 160 km of new lines and open 78 metro stations from 2011 to 2020.

Thus, the common factors influencing the health state of the population of the Beijing and Moscow regions include the strong anthropogenic transformation of the territory, significant traffic load, and poor state of the atmosphere.

Specific factors in Beijing include shortage of water resources and poor quality of drinking water, fuel and energy system that uses coal as fuel, and extreme climatic conditions. In Moscow, these factors typically do not have a pronounced negative impact on the health state of the population.

Analysis of the ***medico-demographic situation*** in the considered regions has identified population growth as the important factor of impact in Beijing, where in the period from 1949 to 1990, the population has increased from 2 to 10 million, reaching 19.7 million in 2010. In addition, in 2010, 2.3 million migrants were recorded.

The growth of the population of Moscow is quantitatively less pronounced; however, the rate of increase is very similar. Thus, from 1969 to 2010, the population has increased from about 6 million to 11.9 million.

Life expectancy for the population of Beijing in 2010 was 80.5 years, with 78.6 years for men and 82.4 years for women. The population older than 60 years and older than 65 years is 13.1 % and 8.4 % of the total number of residents, respectively.

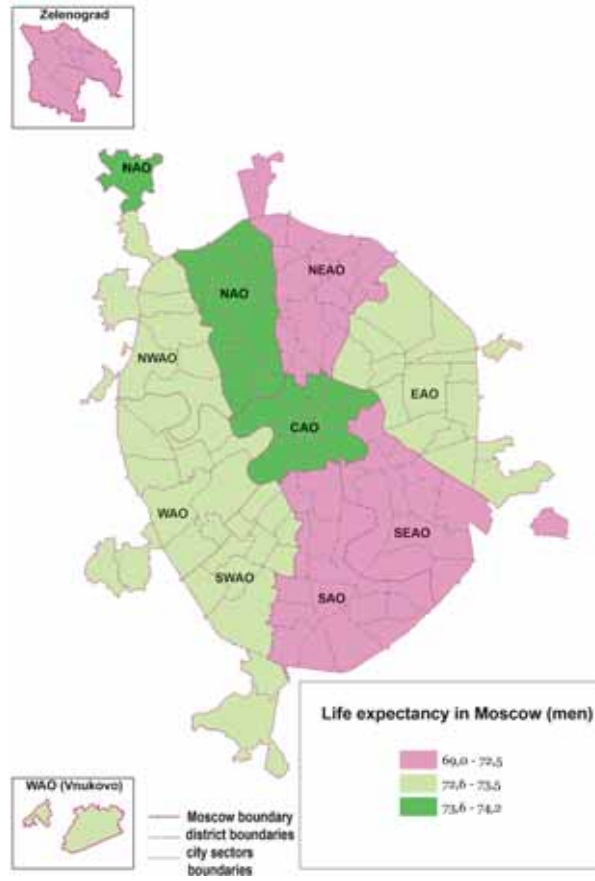


Fig. 3. Life expectancy)

a – men

Life expectancy in Moscow is lower, i.e., 73.6 years, with 69.4 years for men and 77.7 years for women (Fig. 3 a–b).

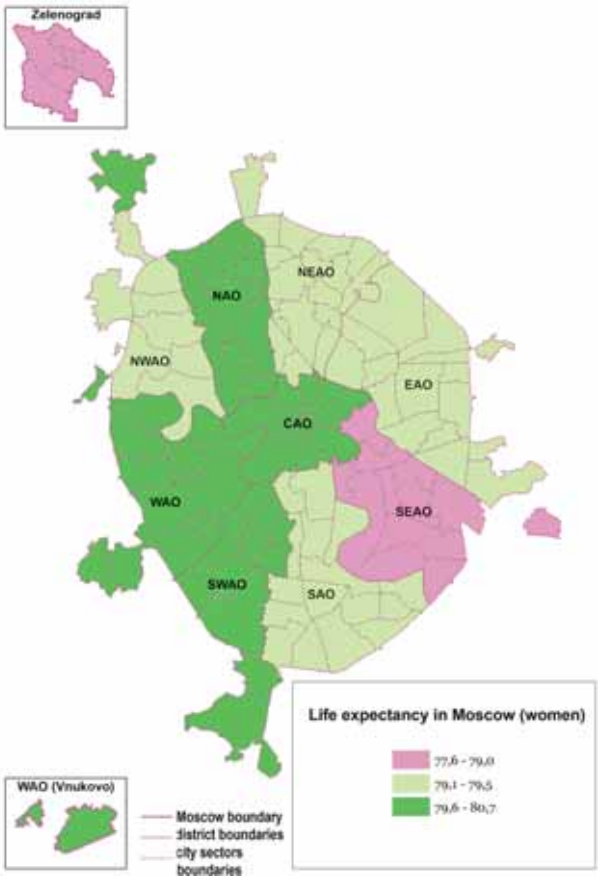
The main causes of death in Beijing are cancer, cardiovascular diseases, respiratory diseases, injuries and poisoning, and diseases of the endocrine system. Mortality from cancer is 25.7 % of total mortality and has the annual growth of 2.5 % over the past 10 years. Prevailing malignancies include lung and breast cancer.

The main causes of death in Moscow are diseases of the circulatory system (55 %), malignant neoplasms (17 %), injury and poisoning (15 %), digestive diseases (6 %), and respiratory diseases (5 %).

Considering the state of health of the analyzed regions, it should be noted that in Beijing, there is a significant incidence of infectious diseases, including intestinal infections (typhoid, paratyphoid, bacillary dysentery, and infectious diarrhea) (Figs. 4 and 5).

The return of some particularly dangerous infectious diseases, such as the plague, is becoming relevant to the territory of China due to climate change [Wang et al, 2009].

The special problems include periodic *emergence and spread of new infections in the region*, such as SARS, swine flu, etc. Epidemics occur usually in cities with a significant concentration of people [Ngeow et al., 2005; Zhou et al., 2011; Yang et al., 2012].



in Moscow (2010)

b – women

In Moscow, there is prevalence of chronic diseases such as cardiovascular disease (648 per 100 000 population), malignant neoplasms (209 per 100 000 population), digestive diseases (44 per 100 000 population), and respiratory diseases (28 per 100 000 population) (Fig. 6).

CONCLUSION

Analysis of the medico-geographical situation of the studied regions led to the following conclusions. Despite the fact that these regions have a number of similar environmental factors affecting the health status of the population (such as the strong anthropogenic transformation of the territory, significant traffic load, and poor state of the air quality), differences in natural conditions result in significant differences in the state of the population health. Lifestyle of the population, including in the historical past, obviously plays the important role.

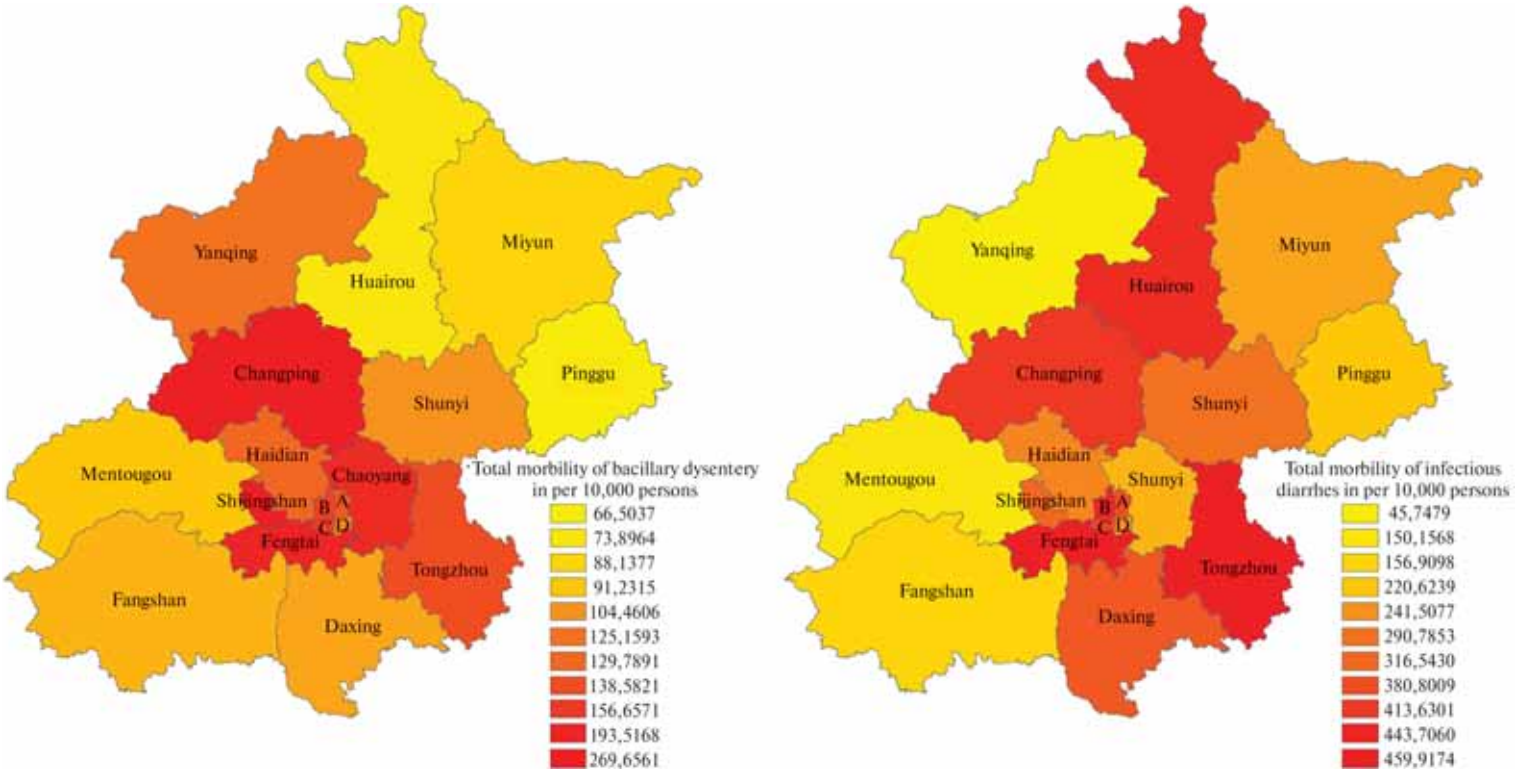


Fig. 4. Morbidity of bacillary dysentery and infectious diarrhea in Beijing (2010)

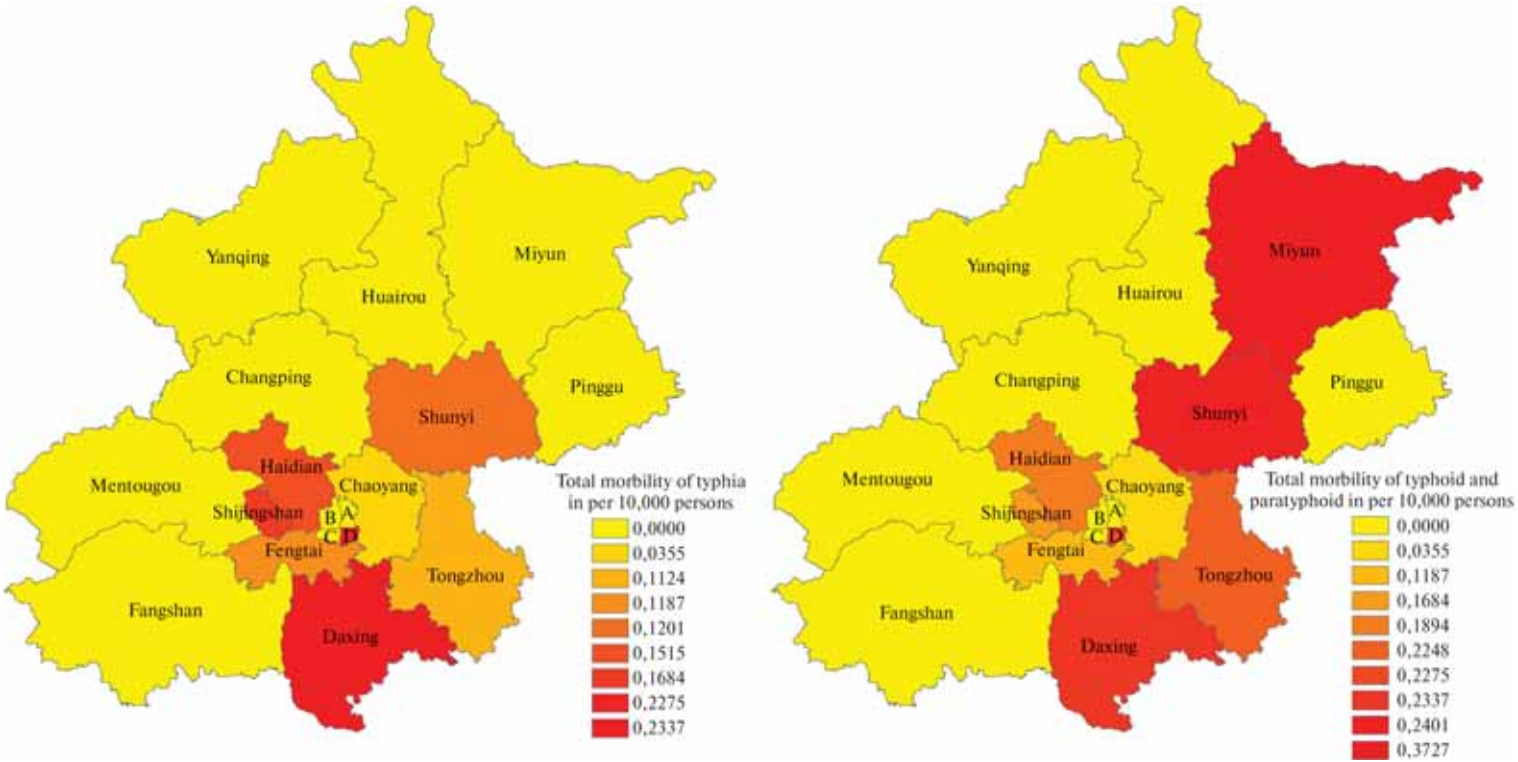


Fig. 5. Morbidity of typhia and typhoid in Beijing (2010)

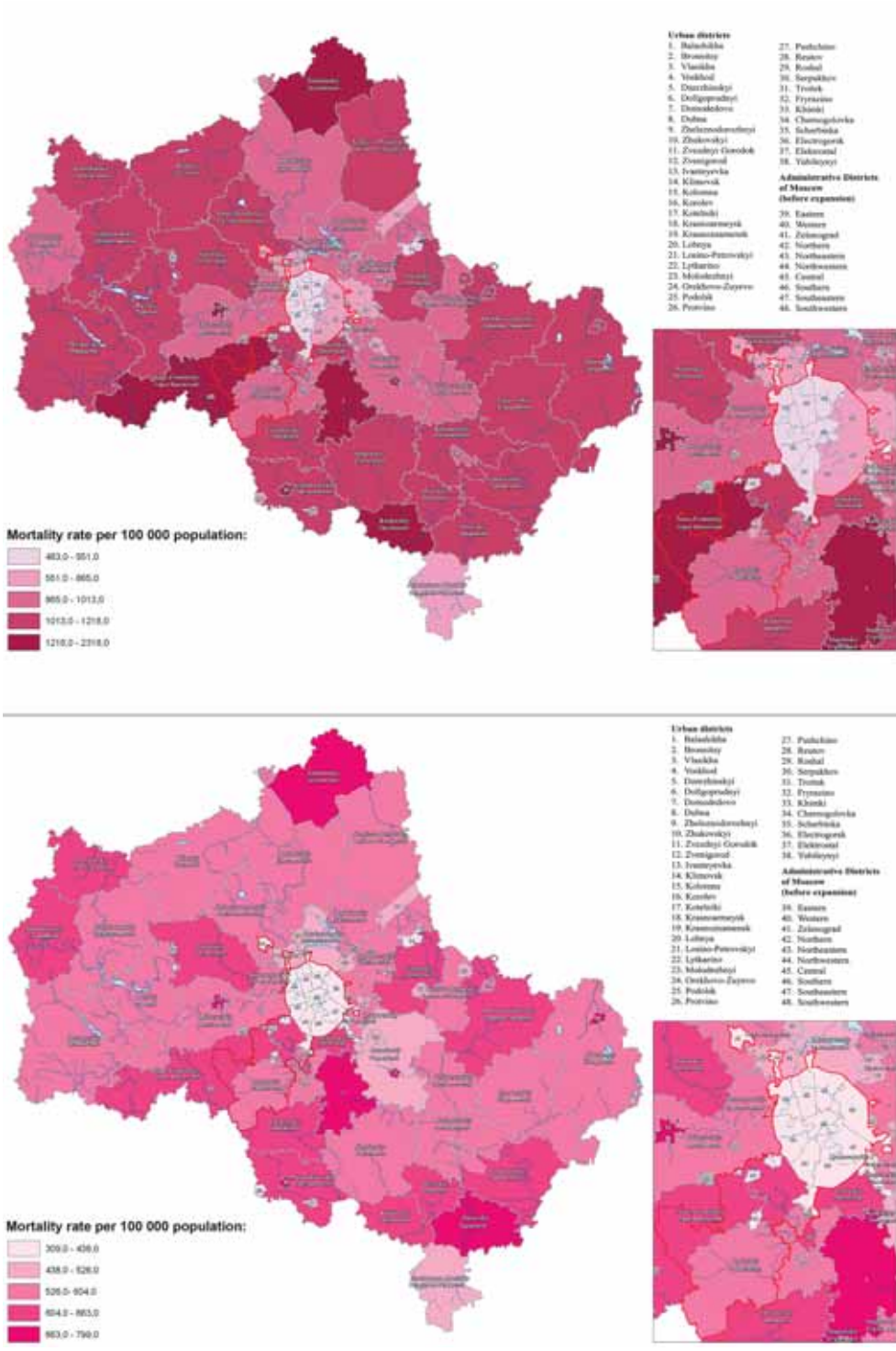


Fig. 6. Mortality from cardiovascular diseases in cities and districts of the Moscow region (2010):

a – men, b – women

Varying degree of intensity of socio-economic changes is also reflected in the state of the population health. The rapid development of new areas of Beijing attracts a significant number of migrants and entails outbreaks of infectious diseases. The long-term development of the Moscow region, as a large industrial center, results in the high level of chronic non-communicable diseases.

Significant differences in the major causes of mortality and life expectancy can be associated with the organization of the health system in the regions and levels of its development.

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EXPLOITATION OF ENVIRONMENTAL RESOURCES AND RURAL COMMUNITIES BY GLOBAL FOOD COMPANIES

ABSTRACT. Globalization is determined by creation and growth of global capital markets for goods and services at international trade and environment level. In year 2013, the total food sales of the top 100 food companies in the world amounted to US$ 1,332,070 million. The headquarters of these companies are established in 20 different countries in 6 different geographical areas. The food sales comprised of 39 % from North America, 32 % from Europe, 21 % from Eastern Asia, % 3 from South America, 3 % from Nordic, and 2 % from Oceania. Globalization potentially creates monopolies. Most of the literatures on environmental issues indicate that these companies increase their profits in three ways: cheap labour, unethical policies, exploitation of environmental resources.

KEY WORDS: Global food companies, strong environmental sustainability, exploitation of environmental resources, rural population

INTRODUCTION

"Globalization" is one of the most popular terms used recently. Burke [1998: 91] identifies globalisation as "creation and growth of global capital markets for goods and services in terms of international trade and environment level". Globalisation has advantages and disadvantages. One of the disadvantages of globalisation is monopolies. Vertical or horizontal firm cooperation may cause monopolies [OECD, 1998; Potter, 2011; Shukla, 2004]. For instance Nestlé, a Switzerland company, markets foods such as milk, cereals, baby food, bottled water, pet food, and ice cream all over the world. Nestlé is also in cooperation with New Zealand's Fonterra, Dairy Partners of America. France's Danone [Groupe Danone, 1996], Italy's Parmalat [Goldberg, 2005], Ireland's North Kerry Milk Product [Bernardi and White, 2006], and India's Kohinoor Foods Limited [Malcolm, 2010] are important food companies on the global scale.

These companies operate through "win-win strategies" [Chung and Gillespie, 1998]. However if there is a "winner" with the aim of gaining maximum profit, it means there is also a "loser" somewhere. Kumar and Budin [2006: 743] presented a diagram at the Conference of Global Business showing the food supply process from farming to consumers. The diagram comprised of five steps: Farming, co-op processing, manufacturing, consumer interface, consumers. The chain was considered very important in delivery products to consumers without contamination. However some significant points have been forgotten: The consideration for natural or environmental resources and social side of production such as rural population and brown revolution. For example Kumar and Budin mentioned the use of water at the co-op processing [p. 743] stage but not environmental resources. Interestingly there was not any subject related to either environmental resources or brown revolution at the conference [Global Business, 2006]. It is assumed companies would have taken seriously the ways in which they could profit without having a negative impact on environmental resources and rural population.

Environmental resources [ER]

Marketing researches focus on what consumer wants [Gottfredson and Aspinall, 2005] However global firms do not think what environment wants. Business, management or marketing researches mention explaining of a variety of models: ANDC [Andctor Error Correction] model [Teweldemedhin, 2011], CSR [Corporate Social Responsibility] and Y value system [Prado and Merlo, 2011], WFGM [Want, Find, Get, Manage] [Garcia, 2011], FSE frame model [Food Security Equation] [Pacheco de Carvalho, 2011]. For example there are 4 stages for FSE. One of them is ecological equilibrium. Pacheco de Carvalho [2011:18] tried to explain food balance through an equation but there was not any component related to environmental resources in this equation. Ecological certification was also mentioned in researches [Gomes and Neands, 2011; Padula, Oliveira, Centenaro, Fornazier, Pozas, Steffens, 2011]. Prado and Merlo [2011] explained CSR and Y value system and there were sustainable environmental components in this system. However ecological components were very superficial at these researches.

The annual conference of IFAMA [International Food and Agribusiness Management Association] was held at Frankfurt in 2011. There were 192 oral presentations at the conference. It was seen that environmental subjects were rarely referred at researches [Gomes and Neves, 2011; Neves, 2011; Pacheco de Carvalho, 2011; Padula et al., 2011; Prado and Merlo, 2011,] and these researches had anthropogenic perspective. Neves [2011: 5] mentioned the importance of environmental resources for food sector and investment. But the first important subject was governance structure of the investments [for instance money entrance, joint-ventures, vertical integration, franchisees etc] and the second one was environmental protection according to Neves.

CEO of Nestlé said that they helped to develop of rural area and low- income producers [Goldberg, 2005]. According to Sustainability Report of Danone [2011], the company was fairly successful in terms of environmental sustainability [Danone, 2011: 66–67]. It is thought that this is visible side of an iceberg.

Brown revolution

The basic food resource of world is agriculture. One third of the world population is related to agriculture directly or indirectly. The main parts of agriculture are cereal, oil, livestock, fish, and water according to United Nations. Especially population of rural area is interested in agriculture. Unfortunately some wrong national macro policies which of them also related to global firms and international trade cause poverty in rural area and the population of rural area migrates to developed countries as refugee to have more qualified life. [FAO, 2003] This migration is called "brown revolution" [Economist, 2002]. According to United Nations [2014] statistics there are more than 43 million refugee all over the world in 2014; it means nearly 0.6 % of the world population survive as refugees. The urban population was around 3.8 billion and the rural population was around 3.3 billion in June, 2014 [UN, Department of Economic and Social Affairs, 2014]. The urban and rural ration is nearly 1:1 however the urban population is more than the rural population.

This migrant population settles urban area and this massive population also stresses on urban life especially in Asia, Sub-Sahran Africa, Latin America [World Agriculture, 2003]. The rural population is also exposed to nonadaptation in urban social life and a gap is become between expectation and reality. The Economist [2002] says that brown revolution is unstoppable. The World Agriculture report of FAO [2003] says that stopping the brown revolution is not desirable as economically. However it might be slowed. On the other hand World Agricultural Report [2003] report utters that governments should support the rural population life with internal and

external policy. The Economist [2002] calls revival of rural population as "green revolution". Rural development is now more important than urban development because geographic location is an essential factor for determining the development of rural area and economy [World Agriculture, 2003]. The studies usually focus on supporting of urban development in terms of OECD, developing or undeveloped countries [Cole, 2000; Diesendorf and Hamilton, 1997; FAO, 2003; Goudie, 1982; Mol, 2001; OECD, 1998; World Agriculture, 2003]. But firms or companies are global so global companies cause rural to become underdevelopment.

Is it really true that global firms support rural development? There are a variety of ecological perspective: ecopedagogy [Kahn, 2010], ecocentric dark green environmentalism, light green anthropocentric environmentalism, Eco-Marxisizm, ecofeminism [Lummis, 2002], ecocentrism, technocentrism [Gough, 1997] etc. The aim of this study is not to explain ecological perspective one by one but technocentrism is a kind of managerial and anthropocentric approach to natural environment. The usage of ER is licit for human development, security, welfare according to technocentrism [Slater, 1991; Gough, 1997]. However it is known that technocentrism promotes weak environmental sustainability [WES] [Cole, 2000].

WES might be occurred by Mickey Mouse [MM] economic model and most of the developing countries use this model. According to MM economy is the biggest part of development [head of mouse]; ER and social components have the second importance [ears of mouse]. [SANZ, 2009] By the way there is a contradiction between Malthus Theory and MM model. Malthus says that increment of human population is related to ER. Human population increases as geometrically while ER increases as linearly [Malthus, 1973]. There is unbalance between population and ER [Seidl and Tisdell, 1998] so it may cause WES. However it is needed strong environmental sustainability because ER is very limited. [SANZ, 2009]. It is thought that Mickey Mouse economic model is also used by global firms.

Population biology tries to explain Malthus Theory by formula or modelling study [Emmel, 1976; Seidl and Tisdell, 1998; Singh and Uyenoyoma, 2004]. It is thought that human individualism/ selfishness should be also added to formula or modelling study. Allaby [1986: 180] says that some parts of the world produce much more food than the other parts of the world. This situation is probably still same because some researches emphasize that 20 % of world populations consume 80 % or 86 % of the goods and services brought by the global economy [FAO, 2003; Stahel, 1998]. In this perspective the aim of this study is to take attention dangerous of global food companies on environmental sustainability and rural population.

METHODOLOGY

It was determined firstly which global companies had the most effective profits. Food Engineering [2014] published the "The World's Top 100 Food & Beverage Companies' [App. 1]. This list only included company name in terms of rank and food sales [$ million] according to 2013. The author also determined the headquarters of companies through websites of them and classified the headquarters according to geographical areas. Descriptive analyse was used in order to evaluate Appendix 1.

RESULTS

Common properties take attention among these top companies. These are:

a. They are global companies

b. They have agents and sales all over the world

c. Most of them have wide range of products.

d. Most of them have environmental sustainability reports [for instance Danone,

Table 1. Classifying of Global Food Firms According to Country and Geographical Area

Geographical area	Country name	Number of company	%
North America	USA	32	39
	Mexico	3	
	Canada	3	
	Cuba	1	
Europe	France	8	32
	UK	5	
	Germany	5	
	Netherlands	4	
	Switzerland	4	
	Italy	3	
	Ireland	1	
	Belgium	1	
	Austria	1	
Eastern Asia	Japan	17	21
	China	3	
	Thailand	1	
South America	Brazil	3	3
Oceania	Australia	1	2
	New Zealand	1	
Nordic	Denmark	3	3
	Total	20	100

2011; Nestle, 2011] and these companies are successful in terms of sustainable development or environmental sustainability. The aim of this study is not to cruise these reports one by one but it is thought that report results draw a pink table for human population and future.

In year 2013, the total food sales of the top 100 food companies in the world amounted to US$ 1,332,070 million. The most food sales is done by Nestle [77,810 million $, App. 1] but USA has the most of the top global food companies [32]. The headquarters of these companies are established in 20 different countries in 6 different geographical areas. The food sales comprised of 39 % from North America, 32 % from Europe, 21 % from Eastern Asia, % 3 from South America, 3 % from Nordic, and 2 % from Oceania. Globalization potentially creates monopolies. [Table 1]

DISCUSSION

It is understood that developed and developing countries direct food sector according to Table 1. But the big question is how these companies increase profit every year because companies' annual reports are very positive. It is clear that global companies promote job opportunity, salary etc. Peter Brabeck, CEO of Nestle, says Nestle has around 4.5 million employees directly or indirectly [Wagenhofer, 2005]. How do they earn much more money in spite of having more employees? Do they also have endless ER? World is a close system and ER is very limited.

The author could not find case studies related to profit resources of global food companies in scientific articles or books but there are interesting and significant case studies or examples at documentaries [Francis and Francis, 2006; Garcia, 2004; Sarkar and

Subramanian, 1996; Soechtig and Gibson, 2009Wagenhofer, 2005;], magazine [National Geographic], and other popular books [King and Lessidrenska, 2009]. Case studies of these resources are coherent each other. It is obvious that global food companies increases their profits by three ways: cheap labour, wrong policy, exploitation of ER.

Cheap labour

Cheap labour helps to increase profit of companies. Cheap labour is obtained by rural population but unjust global competition causes to loose job of rural population [Goldberg, 2005]. Romania is the second agricultural country after France in Europe and daily wage of labourer is 50 cent in Bralia area, Romania. Jean Ziegler, UN Special Reporter on the Right of the Food, says that Switzerland has not got any natural resources but banking sector is very developed. Agriculture is efficient but very limited in Switzerland. It imports 4/5 of grain for bread from India despite there is a lot of unnourished people in India. [Wagenhofer, 2005].

The other weird thing is EU and USA governments subsidize own farmers to go on agricultural production and exportation. People can find easily agricultural products of EU or USA with third one lower of local prices at Sandagar Market where is in Dakar, West Africa. Rural farmers cannot compete with cheap prices so gained up everything and migrate to West countries to find a job. On the other hand, rural farmer De- Souza from Pernambuco/ North- eastern, Brazil says that government does not subsidize little farmers so they are hungry and they cannot survive. However Brazil is one of the richest agrarian countries and the largest soya exporter of the world. [Wagenhofer, 2005; Wallace, 2007].

Similar results also happened in Sri Lanka for planting rice [Sarkar and Subramanian, 1996], in Romania for planting of vegetables [Wagenhofer, 2005], in Ethiopia for planting coffee [Francis and Francis, 2006]. 842 million people in the world suffer from permanent and extreme malnutrition in 2005 [Wagenhofer, 2005]. These people are hungry despite of having job because wrong policy is also affected on rural population.

Wrong Policy

Governmental agriculture policies support technology, industrialisation, and development but side-effects happen at the same time. Market fishing is absolutely industrialized in Europe and most of the fish are wasted during marketing process so small fishing is needed. In this way people can eat fresh fish but EU does not support small fishing. On the other hand a farmer from Germany says that there is decreasing number of farmers since Germany joined to European Union [EU] and most of these people retired or change the job [factory etc]. Farming people now grows up maize in Germany [Wagenhofer, 2005; Wallace, 2007]; plant corn, soybean, and sugar cane in USA and Brazil [Bourne, 2007] for fuel not for feeding. EU does not support agriculture and wants maximum product by minimum farmers and maximum technology. But side effects of technology are again unavoidable.

Lieven Bruneel, who is Agronomist, says Almeria/Southern Spain is capital of winter vegetables agriculture. Agricultural area in Almeria is 25.000 ha but people do not earn much more money since last 10–15 years. Urbanization is also happened around Almeria. Almeria lost agricultural marketing all over the world because soil quality is lower despite of technological agricultural methods, by the way quantity of products decreased. [Wagenhofer, 2005] Similarly farmlands in Haiti [Bourne, 2008], Yunnan Province [China], Loess Plateau [Zizhou Country- China], Grand Valley [Colorado], The Palouse Hills [Washington State], Issa Aminatou of Keita [Niger], Gourcy [Burkina Faso], Amazonia [Brazil] lost their soil quality because of wrong agricultural policies [Mann, 2008].

Karl Otrok, Director of production at Pioneer Romania, says Pioneer is largest seed producers in the world. The company uses hybrid seeds in terms of marketing strategies

but he also warns they cannot use any seed to produce another generations. The taste of hybrid products is not as tasty as natural ones and natural seeds cannot also cope with hybrids seeds. This circulation damages natural life. [Mann, 2008; Wangenhofer, 2005]. Big seed companies want rural farmers to use hybrid seeds. Hybrid seeds are used for tomatoes, potatoes, onion, sun flower, eggplant, soya bean etc. [Garcia, 2004; Wangenhofer, 2005]. It is suspicious that if there is no seed how human would survive in further times. Is technology enough to survive?

Exploitation of ER

Wrong policy and wrong consumer behaviours give rise exploitation of ER. Millions of people have not got enough food but farmers grow maize for fuel not for feeding in Germany now. On the other hand the other farmer says that 2 million kilos bread in a year has gone to waste basket in Germany and similar event happens in Vienna. However Germany imports wheat from other developing or underdeveloped countries. [Wagenhofer, 2005]. Developing and underdeveloped countries destroy natural environment to have more profit. Biolog Vincent Jose Puhl says the largest soya producer of world is Maggi group in Mato Grosso, Brazil. Soya exports to Europe, China, and Japan. Amazonia Rain Forest is destroyed to open farm land since 1975 and one square meter of forest is sold for one cent. Cleared area is used to plant soya but this land is not suitable to grow up soya so farmers use fertilizers. [Wagenhofer, 2005; Wallace, 2007; Mann, 2008].

Peter Brabeck [CEO of Nestle] says social responsibility of a CEO is to have profitable future. He says that people believe everything comes from nature. Nature is pitiless. Human put balance between nature and civilization. Nestle is the biggest bottled water supplier. According to Brabeck, water is not a human right; it is only a foodstuff and it can be sold. [Wagenhofer, 2005].

75 % of world is covered by water but only 1 % of this water is drinkable. Some of the drinkable water is under ground. [Tundisi & Tundisi, 2012]. On the other hand, Nestle under Poland Spring brand uses water resources of rural areas to produce bottled water in USA and 3.6 billion bottled water sales were done by Nestle in 2008 [Soechtig & Gibson, 2009]. Similarly Coca Cola is drainage the groundwater of India for producing cola and bottled water [King & Lessidrenska, 2009]. This ground water is water resources of rural populations.

There are 193 countries in UN [UN, 2012] but top 100 global food companies are in 20 countries. It means 10.36 % of world governs rest of the world in terms of food and it is unfair. It is just like `Hunger Games`. There is central area, Capitol, in Hunger Games and another 12 districts depend on Capitol. Every district area is specialised to produce something [agriculture or mine] and they have to send most of the production to Capitol. Capitol is very rich but districts are very poor. [Collins, 2008]. Now Capitol is Europe and North America according to Table 1. Rest of the world may be divided 7–8 districts in terms of continentals. There has not happened yet any war for food but most of the scientists warn about water scarcity and water wars [Buu, 2010]. CEO of Nestle Brabeck says water is not a human right; it is only a saleable foodstuff. Similarly Stiglitz [1974] warned about ER was evaluated as capital good in 1974. This perspective is still same. But it is not true. 70 % of human body consist of water and everybody needs it. In terms of Brabeck, rich people may have water or food. What about rest of population?

Human should prefer one of the ways anymore: Best taste and low price marketing or least taste and high price. People should think global and act local because ER is very limited and we do not have any planet to live. All governments should support and subsidize rural agriculture and population; in this way reverse migration should happen to rural area. Gough [1997] says environmental knowledge and life style of rural people are very important to have strong sustainability because they know how to live at own land as peacefully. It

is understood urbanization/ brown revolution is another problem from governments and nobody could this problem yet.

Brown revolution also gives rise to WES. The Economist says urbanisation is not stopped anymore but it is not true. Human needs green revolution. People migrate for surviving. If they could survive own rural area, why would they like to migrate? Also they are happy at their heritage lands. Urbanisation does not give happiness [Passador, Junior, Artoni, Passador, 2011]. This is also a sociological perspective and should be researched. Brown revolution is harmful either environmentally or sociologically. Stahel [1997] says trivets of sustainability are nature conservation, health and safety, reduced flows of materials, social ecology, and cultural ecology. Human need green revolution and it may give us strong environmental sustainability.

CONCLUSION

There is an idiom at trade: Big fish eats small fish. Who knows what will happen in further times about economy? Big companies may purchase small companies and it may give rise to more monopolies. Economic power should spread out to rural. Now there is drought at West Africa and it is wanted donation by advertisement on TV. Donation is not a solution. It should be taught to fish; not to eat fish. Wrong economic and ecological policies may give rise to drought, such as in Haiti [Bourne, 2008]. The aim of this study is to take attention dangerous of global food companies on environmental sustainability. The author tries to give a general evaluation about global food companies. They have financial power but money is not enough to have strong sustainability. Stahel [1997: 486] emphasizes "higher resource productivity entails higher economic and ecologic benefits." Every company [App. 1] may be evaluated in terms of own trade activity one by one.

Production and consumption are just like Siamese twins. It is thought that consumer education might be effective on production. West countries might be extravagant [Wagenhofer, 2005] while West Africa needs food [Bourne, 2008]. Doherty and Taplin [2008] undertook the research on relationship between consumer education and being global citizenship. They study with 7–14 years old school children and find that there is positive relationship between consumer education and global citizenship. However they do not explain environmental roots or benefits of consumer education. Global citizenship is related to strong sustainability directly. People may raise awareness about global effect of personal consumer behaviour by formal and informal education. It is thought that remarkable case studies should be explained to have clear understanding about environmental effects of people on natural environment. People-especially Western people-should empathize with other people because responsible consumer behaviour might be effective on responsible production behaviour or strategy. Otherwise Hunger Games might happen in future. ■

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Emel Okur-Berberoglu – the theme and experimental sequence of her Ph. D. dissertation constituted a number of research projects related to outdoor environmental education intended for in-service teachers. These projects were funded by TUBITAK (Scientific and Technology Research Council of Turkey) and were within science and society projects. She collaborated with colleagues from different disciplines (Education, Biology, Ecology, Geology, Herpetology, Archaeology, Marine Ecology etc.) within these projects and especially focused on environmental education for sustainable development and globalization.

Appendix 1

Top100 Global Food Companies (2013)

Company	Country	Geographical Area	2013 Food Sales
1. Nestlé	Switzerland	Europe	77,810
2. PepsiCo, Inc.	USA	North America	66,415
3. The Coca-Cola Company	USA	North America	46,854
4. JBS	Brazil	South America	44,700
5. Archer Daniels Midland Company	USA	North America	43,195
6. Anheuser-Busch InBev	Belgium	Europe	43,195
7. Mondelez International	USA	North America	35,299
8. SABMiller	UK	Europe	34,084
9. Tyson Foods	USA	North America	34,374
10. Cargill	USA	North America	33,500
11. Mars	USA	North America	33,000
12. Unilever	UK-Germany	Europe	31,685
13. Danone	France	Europe	29,605
14. Heineken	Netherlands	Europe	26,692
15. Lactalis	France	Europe	22,240
16. Kirin Holdings	Japan	Eastern Asia	21,246
17. Asahi Breweries	Japan	Eastern Asia	19,195
18. Suntory	Japan	Eastern Asia	19,193
19. Kraft Foods	USA	North America	18,218
20. Diageo	UK	Europe	18,180
21. General Mills Inc.	USA	North America	17,774
22. Royal FrieslandCampina	Netherlands	Europe	15,870
23. Fonterra	New Zealand	Oceania	11,260
24. ConAgra Foods Inc.	USA	North America	15,491
25. Brf Brasil Foods	Brazil	South America	15,260
26. CHS Inc.	USA	North America	14,900
27. Kellogg Company	USA	North America	14,792
28. Arla Foods	Denmark	Nordic	13,505
29. Grupo Bimbo [Mexico]	Mexico	North America	13,466
30. Smithfield Foods Inc.	USA	North America	13,221
31. NH Foods	Japan	East Asia	12,405
32. Associated British Foods	UK	Europe	12,135
33. Pernod Ricard	France	Europe	11,920
34. Femsa	Mexico	North America	11,920
35. Carlsberg	Denmark	Nordic	11,810
36. Meiji Holdings	Japan	Eastern Asia	11,565
37. HJ Heinz Company	USA	North America	11,529
38. Ferrero	Italy	Europe	11,260
39. Bunge	USA	North America	11,177
40. Vion	Netherlands	Europe	10,975

Continue

Company	Country	Geographical Area	2013 Food Sales
41. Sudzucker	Germany	Europe	10,750
42. Danish Crown	Denmark	Nordic	10,675
43. Yamazaki Baking	Japan	Eastern Asia	10,210
44. Coca Cola HBC	Switzerland	Europe	9,555
45. Maruha Nichiro Holdings	Japan	Eastern Asia	9,530
46. Marfrig Group	Brazil	South America	9,400
47. Saputo	Canada	North America	9,050
48. Dean Foods Company	USA	North America	9,016
49. Hormel Foods Corporation	USA	North America	8,752
50. Coca Cola Enterprises	USA	North America	8,212
51. Kerry Group	Ireland	Europe	8,115
52. Campbell Soup Company	USA	North America	8,052
53. Yili Group	China	Eastern Asia	7,585
54. Parmalat	Italy	Europe	7,436
55. DMK Deutsches Milchkontor	Germany	Europe	7,365
56. Ajinomoto	Japan	Eastern Asia	7,185
57. The Hershey Company	USA	North America	7,146
58. Oetker Group	Germany	Europe	7,100
59. Red Bull	Austria	Europe	7,005
60. Sodiaal	France	Europe	6,950
61. China Mengniu Dairy Company	China	Eastern Asia	6,885
62. McCain Foods Ltd	France	Europe	6,860
63. Morinaga Milk Industry	Japan	Eastern Asia	6,825
64. Muller Group	Germany	Europe	6,810
65. Grupo Modelo [Mexico]	Mexico	North America	6,776
66. Ingredion Inc.	USA	North America	6,653
67. Nissui	Japan	Eastern Asia	6,145
68. Bongrain	France	Europe	6,128
69. Dr Pepper Snapple Group	USA	North America	5,997
70. LVMH	France	Europe	5,820
71. McCormick Corporation	USA	North America	5,730
72. The JM Smucker Company	USA	North America	5,611
73. Bacardi	Cuba	North America	5,600
74. Nisshin Seifun Group	Japan	Eastern Asia	5,390
75. Itoham Foods	Japan	Eastern Asia	5,280
76. Sapporo Holdings	Japan	Eastern Asia	5,170
77. Tate & Lyle	UK	Europe	5,003
78. Ito En	Japan	Eastern Asia	4,985
79. Barilla	Italy	Europe	4,915
80. ThaiBev	Thailand	Eastern Asia	4,850

Continue

Company	Country	Geographical Area	2013 Food Sales
81. Maxingvest/Tchibo	Germany	Europe	4,810
82. Nissin Food Products	Japan	Eastern Asia	4,757
83. Barry Callebaut	Switzerland	Europe	4,696
84. Coca-Cola Amatil	Australia	Oceania	4,620
85. Schreiber Foods	USA	North America	4,500
86. Land O' Lakes Inc.	USA	North America	4,498
87. Coca Cola West	Japan	Eastern Asia	4,495
88. QP Corporation	Japan	Eastern Asia	4,475
89. Tsingtao Brewery	China	Eastern Asia	4,408
90. Maple Leaf Foods	Canada	North America	4,292
91. Dole Food Company, Inc.	USA	North America	4,247
92. Molson Coors Brewing Company	USA	North America	4,206
93. J R Simplot	USA	North America	4,100
94. Japan Tobacco International	Switzerland	Europe	4,035
95. Hillshire Brands	USA	North America	3,920
96. Del Monte Foods Company	USA	North America	3,819
97. Groupe Bel	France	Europe	3,780
98. Agropur Cooperative	Canada	North America	3,770
99. DE Master Blenders 1753	Netherlands	Europe	3,605
100. E. & J. Gallo Winery	USA	North America	3,600
Total			1,332,070

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NEW PERMAFROST FEATURE – DEEP CRATER IN CENTRAL YAMAL (WEST SIBERIA, RUSSIA) AS A RESPONSE TO LOCAL CLIMATE FLUCTUATIONS

ABSTRACT. This paper is based on field data obtained during short visits to a newly formed permafrost feature in a form of relatively narrow, deep crater. Excluding impossible and improbable versions of the crater's development, the authors conclude that it originated from warmer ground temperatures and an increase in unfrozen water content, leading to an increase in pressure from gas emissions from permafrost and ground ice. This conclusion is also supported by known processes in the palaeo-geography of Yamal lakes and recent studies of gas-hydrate behavior and subsea processes in gas-bearing provinces.

KEY WORDS: Yamal crater, tabular ground ice, cryopegs, gas hydrates, climate fluctuations, cryolithozone, pingo, pockmarks

INTRODUCTION

This paper is based on field data obtained during short visits to a newly formed permafrost feature: a relatively narrow, deep crater. As new features like this have been reported recently in a number of mass-media publications, the processes leading to their formation may already be underway elsewhere in the region, making the study of their origin an urgent task.

Our field study included size measurements and photo and video documentation of the feature and the surrounding environment. The main objective of the reconnaissance was to outline the range of possible hypotheses of the crater's formation, to exclude impossible and improbable versions of its development, and to lay a basis for predicting such processes in the future.

No landform like the crater in Central Yamal discussed in this paper has been reported previously. Yet similar forms, seabed pockmarks, have been known and discussed since the 1970's [Hovland and Judd, 1988; 1992; Hovland et al., 2002; Mironyuk and Otto, 2014].

It is established that permafrost prevents the migration of methane from deep-seated hydrocarbon collectors into the upper permafrost and to the surface [Skorobogatov et al, 1998; Rivkina et al, 2006]. Concentration of methane in frozen Quaternary deposits in the Arctic depends on the age, origin and lithology of the permafrost. The gas and gas-hydrate accumulations are localized in the organic-rich horizons [Rivkina and Gilichinsky, 1996; Rivkina et al., 2006].

The authors' main hypothesis for the crater's formation involves the decay of relict gas-hydrate inclusions, the release of gas out of initially frozen deposits enclosing cryopegs and tabular ground ice. This assumption is based on the known cryolithology and

geochemistry of permafrost in the region, with most of the studies performed in the Bovanenkovo gas field investigations [Streletskaya and Leibman, 2003]. The Bovanenkovo studies revealed substantial gas concentrations [Chuvilin, 2007; Yakushev, 2009], which are blocked by the permafrost [Rivkina et al., 2006; Gilichinsky et al., 1997].

The possibility of the release of the gas from the collectors near the surface is shown by methane and hydrogen sulfide effusion under the Barents and Kara seas from 70 to 130 m beneath the sea floor [Rokos, 2009]. Boreholes at Bovanenkovo gas field [Chuvilin, 2007] revealed various gas manifestations, such as emission out of the borehole and high content in the samples, in the depth interval 20 to 130 m. Most of the gas was contained in ice-bearing clays [Yakushev, 2009]. These clays also enclosed tabular ground ice, cryopegs and some voids filled with low-density ice. The maximum gas emission was 14,000 m^3/day [Bondarev et al., 2008]. F. Are (1998) also suggests that gas accumulates in voids within the permafrost.

Studies of gas bubbles in tabular ground ice of the Kara sea region have shown concentrations of methane exceeding that of the atmosphere by an order of magnitude [Lein et al., 2003; Leibman et al., 2003; Streletskaya et al., 2014; Vanshtein et al., 2003]. Analysis of $\delta C^{13}(CH_4)$ in the upper layers of permafrost in Bovanenkovo area returns results around – 70 ‰, indicating a biochemical origin of this gas in organic matter in the permafrost. [Bondarev et al., 2008]. The isotopic composition is within the same range as in tabular ground ice bubbles [Lein et al., 2003; Vanshtein et al., 2003; Cardyn et al., 2007; Streletskaya et al., 2014].

Methane concentration in modern marine sediments may exceed 1 ml/l in the Arctic seas, [Mironyuk and Otto, 2014] while even more than 0.1 ml/l is considered a high concentration [Hovland et al., 2002]. The methane concentration measured in the frozen deposits of coastal exposures on the Yamal can reach 1.7 ml/kg and in tabular ground ice even more, as much as 2.2 ml/kg [Streletskaya et al., 2014].

The release of this gas could be triggered by changes in ground temperature. Ground temperature changes result from fluctuations in both air temperature and snow accumulation. Warmer air can trigger the rapid changes on the surface, thaw ground ice bodies and create thermal denudation landforms (thermocirques) and thermokarst lakes. Probably, the new features found in 2014 result from the same rise of air temperature, but presenting a new mechanism of formation: gas release in the permafrost.

Thus the origin of the Yamal crater hypothesized in this paper is based on the analysis of (a) existing features resulting from gas-release processes in the Kara sea region as analogues of the observed on-shore landform, (b) climate fluctuations that could have caused changes in thermal state of permafrost, and (c) comparison to other landforms connected to tabular ground ice, the salinity of the deposits, and the concentration of organic matter.

STUDY AREA

The central part of the Yamal Peninsula is limited by the Yuribei River in the south and the Nadui-Yakha River in the north, including areas of active gas extraction and transportation. The region is in the zone of continuous permafrost at least 300 m thick, with high tabular ground ice content. In the 2000s, noTable fluctuations of various climatic parameters have been observed (Table 1).

The summer of 2012 and the preceding winter of 2011–2012 were the warmest since 2006 (Table 1). Summer precipitation in 2012 was close to the maximum level for this period, though precipitation during the preceding winter was at a medium level.

The crater is located in the Tundra bioclimatic zone, a subzone of typical tundra, about

Table 1. Main climatic controls of the thermal state of permafrost according to weather station Marre-Sale records (http://rp5.ru/Bovanenkovsky)

Year/summer	Mean annual air temperature, °C	Thaw index, °C · day	Summer precipitation, mm	Winter season	Freeze index, °C · day	Winter precipitation, mm
2006	–8,0	711	201	2006–2007	–3049	136
2007	–5,0	900	146	2007–2008	–2748	218
2008	–5,0	804	385	2008–2009	–2974	253
2009	–8,3	803	244	2009–2010	–3785	140
2010	–8,1	517	204	2010–2011	–2788	247
2011	–4,4	755	188	2011–2012	–2271	190
2012	–4,1	999	305	2012–2013	–3105	144
2013	–8,2	744	244	2013–2014	–3238	–
Mean	–6,4	784	240	–	–2995	190
2014	–	12.06–16.07 (35 days) 178,5	–	–	28.09–11.06 (257 days)	–

17 km west of the Mordy-Yakha River and about 11 km south of Halev-To Lake (69°58′N and 68°22′E). Rolling hills with altitude up to 52 m have gentle slopes descending to small ravines and lakes. The slopes are densely vegetated by willow shrubs up to 1.5 m high. Cryogenic landslides have disturbed the lake shores (Fig. 1). The crater is located on a small hill about 34 m above sea level.

The crater area is within the zone of continuous permafrost. The average ground temperature may be as low as –6 °C, and the active layer is up to 1 m deep. The geological section is represented by silty-clayey deposits, rich in ice and organic matter, bearing several layers of tabular ground ice several meters thick (Ananieva, 1997, Fig. 2).

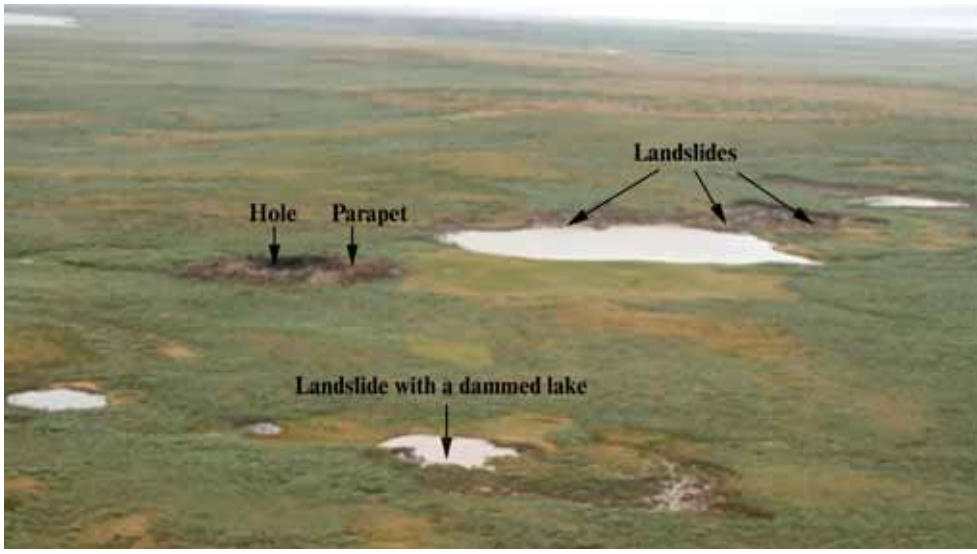

Fig. 1. The crater is encircled by a parapet and surrounded by hills with gentle slopes that are vegetated by high willow shrubs and disturbed by cryogenic landslides (Photo by M. Zulinova, press-service of the YaNAO governor)

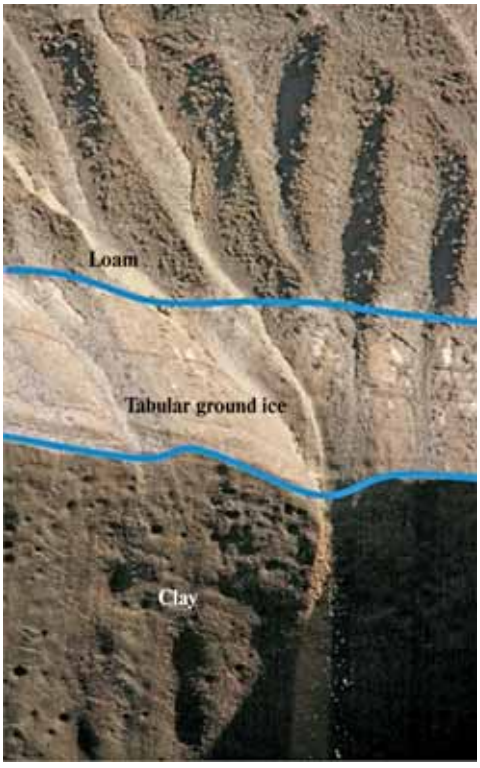

Fig. 2. Clayey deposits within the crater enclose tabular ground ice layers (marked by boundaries) (Photo by M. Zulinova, press-service of the YaNAO governor)

High ice content in the section, observed in the exposures at the shores of Halev-To Lake, is found in the crater's surroundings as well. This conclusion is based on the occurrence of cryogenic landslides, which created thermokarst lakes dammed by landslide bodies (see Fig. 1). Due to the considerable ice content in Central Yamal, a series of cryogenic processes are actively transforming the landscapes in both natural conditions and as a result of human activity [Walker et al., 2011; Kumpula et al., 2011; Gubarkov et al., 2012; Leibman et al., 2014; Khomutov et al., 2014]. Most impressive are the thermocirques, which appeared the last few years in Central Yamal (Fig. 3), [Leibman et al., 2014]. They differ from the crater under discussion in having an outlet to a lake, and were triggered by the unusually warm temperatures in 2012.

Fig. 3. A thermocirque in Central Yamal, east of the Mordy-Yakha River (Photo by Yu.A. Dvornikov, The Earth Cryosphere Institute SB RAS)

STUDY METHODS

The crater was visited on July 16 and August 25, 2014. Close approach was impossible, so the crater was observed from the surrounding parapet. A GPS survey by GARMIN GPSmap 60Sx of the parapet and of the debris that was thrown quite far from the crater was undertaken. Distances were measured with a 30-m tape-line and a laser rangefinder Bosch GLM 250 VF Prof. The depth was measured with a tape and a rope with video camera dropped into the crater. The same camera allowed for a description of the walls deep in the hole, which the sun's light did not reach.

Also roughly measured were the methane concentration, with the help of a gas analyzer SGG-20 tuned to measure methane, and the gamma-radiation with a Geiger counter "SOEKS 01M" in the air around the crater and in the hole. A metal probe was used to measure the depth of the active layer. Professional photography and videography were performed.

Landsat 8 and SPOT 5 satellite images for various time spans were interpreted to determine the time of crater formation. Landsat 8 satellite images were retrieved from the USGS database through the EarthExplorer service [http://earthexplorer.usgs.gov].

A SPOT 5 satellite image was obtained from the archives of RDC "SCANEX" within the framework of the "Geoportal MSU" project.

RESULTS

The landform under study is a crater of a depth about 2 times larger than its diameter, with almost vertical walls. The exposed walls consist of frozen ground, mainly clay, with ice lenses and layers in the lower part and ice of various transparency in the upper portion of the section. The upper 2 m of brownish silty-loamy sediments with peat inclusions represent an active layer covered by clay blocks thrown out of the hole. Below is a thin interbedding of silty and loamy deposits with high ice content (Fig. 4), or rather stratified ice with stratification close to vertical, underlain by dark grey clay with rare inclusions of clasts (see Fig. 2 and 4).

The crater is surrounded by a parapet of thrown out silt, loam, clay and turf blocks. Red, highly ferruginous flat-block surfaces (see Fig. 4, right pane) are evidence of frozen deposits broken along the ice lenses, constituting the reticulate cryogenic structure intrinsic to the clays in the area [Ananieva, 1997].

The upper part of the hole has relatively gentle slopes descending to an overhang, passing downward to steeper slopes and finally to the small lake at the bottom. The shape and size of the walls are changing as the permafrost thaws more quickly where sunlight reaches, and more slowly in the depths of the hole. Runnels of meltwater cut the walls, gurgling down and forming a muddy lake at the bottom. Pieces of turf destabilized as the underlying permafrost thaws fall down with a rumble like that of cannon shot. Thus retreat of the hole's rim is very rapid, probably more than 1 m during the several hours of the July visit.

The diameter of the whole landform was estimated by GPS survey as approximately 70 m outside the parapet. The parapet's width is about 20 m, so the hole must have been no more than 30 m in diameter – less than that (about 25 m) excluding the overhang (Fig. 5). The depth of the hole could not be accurately measured but it exceeds the 50 m to which the rope was lowered and was possibly around 70 m on July 16 and much less (no more than 35 m) on August 25. The depth is changing as the crater fills with mud, turf and water from the thawing permafrost.

Clods of the clay and fragments of turf mat were thrown up to 120 m from the crater (Fig. 6). The farther from the crater, the smaller are the clay clods, from 1 m close to the parapet to several centimeters farthest from the crater. Fragments of turf mat 50–100 cm in size are found up to 60 m away from the crater. Examples of measurements are presented in Table 2 and Fig. 7.

The volume of the parapet is approximately 2000 m^3. At the same time, the volume

Fig. 4. Upper part of the crater wall with interbedding of silty and loamy highly icy deposits and stratified ice, covered by peaty ferruginous active-layer silt and entrained clay blocks on the very top (left pane), clayey blocks contain small clasts (right pane) (Photo by M.O. Leibman)

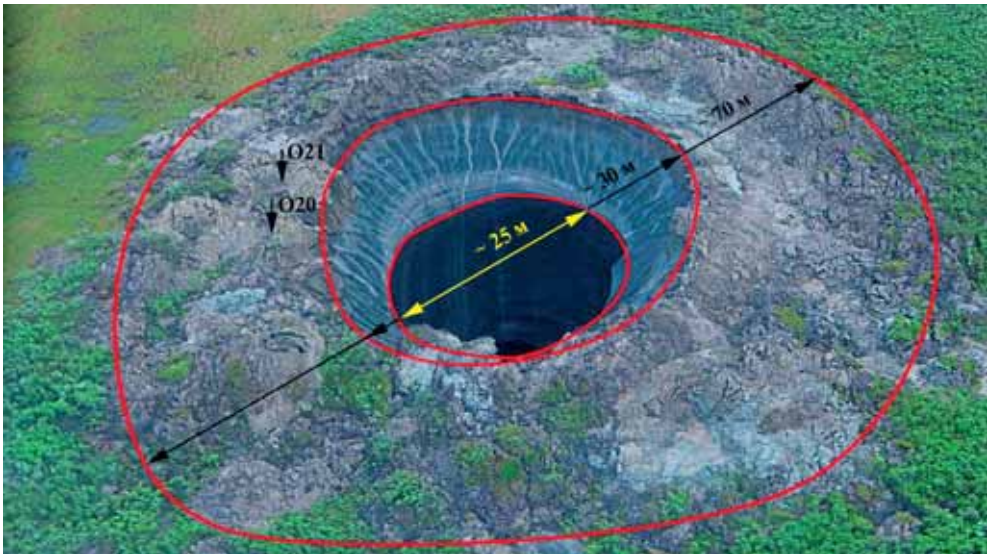

Fig. 5. Parapet, upper funnel, and inner hole size by GPS survey. O20 and O21 points of parapet measurements (Photo by A.V. Plekhanov)

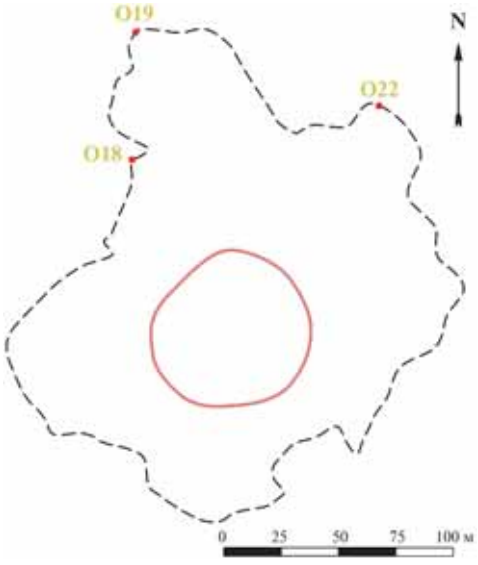

Fig. 6. Crater (solid line) and zone of scattering of ground pieces (dashed line). O18, O19 and O22 are points of block-size measurements (Table 2, Fig. 7)

of the void inside the hole is no less than 25,000 m^3, which is more than 10 times the volume of the parapet. The difference is due to high ice content observed in the crater walls and constituting more than 80 % according to estimate at a glance.

Measurements of radioactivity and methane concentration are presented in Table 3. These measurements showed that radioactivity is at a normal level (0.05–0.14 mSv). Methane concentration range from 2.8–0.3 % outside the hole to 9.6–9.8 % inside the crater. Both values are much higher than normal, and within the crater the concentration is close to explosive (>5 %).

The depth to which the permafrost had thawed, an easily obtained characteristic of the state of permafrost, depends on the thickness of the organic layer, and was 53–66 cm in the

Fig. 7. Examples of scattered blocks of clay turf in the points (left to right) O18, O22 and O19 (see Fig. 6 and Table 2) (Photo by A.V. Plekhanov)

Table 2. Distribution of blocks of clay and turf scattered around the crater and examples (Fig. 7).

Block size, m	Distance from the rim, m	Point ID	Distance from the rim, m	Block size, m
0.5–1	Up to 75	O18	71	1
0.4–0.6	Up to 105	O22	102	0.5
0.1–0.2	Up to 125	O19	123	0.2

Table 3. Methane concentration and radiation measurements in the air around the crater and in the hole

Position of measurement	Distance from the rim, m	Methane concentration, %	Radioactivity, mSv/hour
Parapet O1	520	0	–
Parapet O2	1–2	0.3–2.8	0.05–0.12
Crater	0	9.6–9.8	0.14

lake depression with thick organic cover and 60–77 cm on a slope with willow shrubs and on the parapet. This depth is higher than average for this time of the year, possibly as a result of unusually high air temperatures in June 2014.

Some observations in the vicinity of the crater revealed the following. A lake located about 100 meters from the crater does not have a hydrological connection with it. The high cliffs of lake shore are disturbed by cryogenic landslides. This process occurred most actively in the 1980's [Ananieva, 1997] and serves as evidence of high ice content close to the surface.

DISCUSSION

The permafrost of Central Yamal contains a substantial amount of hydrocarbons in the depths from about 20 m to about 130 m [Rivkina et al., 2006; Rivkin, 1997; Chuvilin, 2007; Bondarev et al., 2008; Lein et al., 2003; Leibman et al., 2003; 2011; Streletskaya et al., 2014]. The depth of the Yamal hole is within this interval. Gas is enclosed in the ground ice and dissolved in unfrozen water. Gas hydrates, though unsTable, can be found at these depths as well in relict (metas Table) form. An increase in ground temperature in the last decade has caused a series of permafrost responses. Partial thaw of ground ice released gas enclosed in the ice [Muskett and Romanovsky, 2012]. Cryopegs respond to temperature and may dissolve the ice with relict gas hydrates and give start to accrescent gas release. Holes in the sea floor formed by similar processes and likewise surrounded by parapets are known as pockmarks [Hovland and Judd, 1988; Melnikov et al., 1997; Mironyuk and Otto, 2014].

Impossible and improbable explanations for the crater formation that can be rejected are: (a) thermokarst (because of the evidence of an uprush of deposits to the surface to form the parapet); (b) burst of pingo (because this would be expected with cooling temperatures and an increase of hydrostatic pressure in the ice-water core of the pingo; in addition, the presence of an ice core at a depth of at least 70 m would be improbable); (c) human activity (because no traces of human activity were observed in the vicinity of the crater); (d) gas combustion (because no traces of fire were observed in the crater or on the nearest slopes); (e) impact of a celestial body (the level of radioactivity is low, and there are no traces of heat; moreover, the pieces of clay are broken along the ice layers, not thawed, while at high temperatures they would have liquefied and formed flows on the surface instead of a parapet).

The features that must be explained are as follows. (1) The depth of the crater exceeds its diameter. (2) The levels of methane and hydrogen sulfide emissions from the permafrost exposed in the hole are high. (3) Clay clods were found at a distance of

120 m from the crater, decreasing in size with increasing distance from the parapet. At a given distance from the crater, larger pieces of turf were found than pieces of clay; turf is much less dense than clay. (4) New leaves on shrubs must have appeared after the parapet formed. At the same time, the hole is not yet filled with water from rain or melting ice.

The age of the feature was determined through the comparison of images for several dates in 2013 and 2014. All available remote sensing data was geo-referenced based on the SPOT 5 satellite image, which had the highest resolution of any available to the moment (Table 4). A GPS-track of the field survey conducted on July 16, 2014 was superimposed on the remote sensing data. The inner circle marks the outer limits of parapet. Its diameter is about 70 m. The outer line marks the area of in which clay blocks have been scattered (Fig. 8).

From the satellite images, we concluded that the crater was formed in the late 2013 or early 2014. One can see that at least until 2013/10/09 in the place of the crater, there is a hill 40–45 m in diameter. After 2013/11/01 satellite images yield a series of pixels of low reflectivity. The size of the area was increasing at least until 2014/04/03. Presumably this specific reflectivity results from water-saturated deposits entrained from the crater forming a parapet along with the hole itself. In summer, when the parapet partially dried up and the barren ground was more reflective, the crater area appeared as a bright ring surrounding the hole.

Thus, based on the remote sensing data, we assume that the crater was formed within the time range from 2013/10/09 to 2013/11/01.

Our hypothesis of crater formation is suggested by the relatively similar in origin features controlled by gassing in permafrost, the occurrence of tabular ground ice and permafrost's response to fluctuations in climate. The least inconsistent mechanism explaining all the observed manifestations is as follows. We expect existence of relict gas hydrates and cryopegs beneath the tabular ground ice bodies in the geological section on study. This suggestion is supported by observations in Central Yamal in thousands of boreholes [Yakushev et al., 2005; Streletskaya, Leibman 2003]. Increasing ground temperatures in the last decade, particularly in 2012, could have released gas both out of permafrost and bubbly facies of tabular ground ice, as well as from decay of gas hydrates. The last gives a large cataclysmic expansion. This expansion which may start from a slow process produces a landform close to the one known as pingo (hydrolaccolith). This form will serve as a limitation factor for localization of the future hole and determine its cylinder shape. In time as gas hydrate decomposition acquires its full strength, the "shot" pops up the

Table 4. Satellite images metadata.

Date	System	Scene ID	Grid cell size panchromatic, m
2014/07/22	Landsat 8	LC81670112014203LGN00	15
2014/04/03	Landsat 8	LC81650112014093LGN00	15
2014/03/16	Landsat 8	LC81670112014075LGN00	15
2014/02/21	Landsat 8	LC81660112014052LGN00	15
2013/11/01	Landsat 8	LC81660112013305LGN00	15
2013/10/09	Landsat 8	LC81650112013282LGN00	15
2013/10/01	SPOT5	142204_1310010650116_1A	2,5
2013/07/03	Landsat 8	LC81670112013184LGN00	15

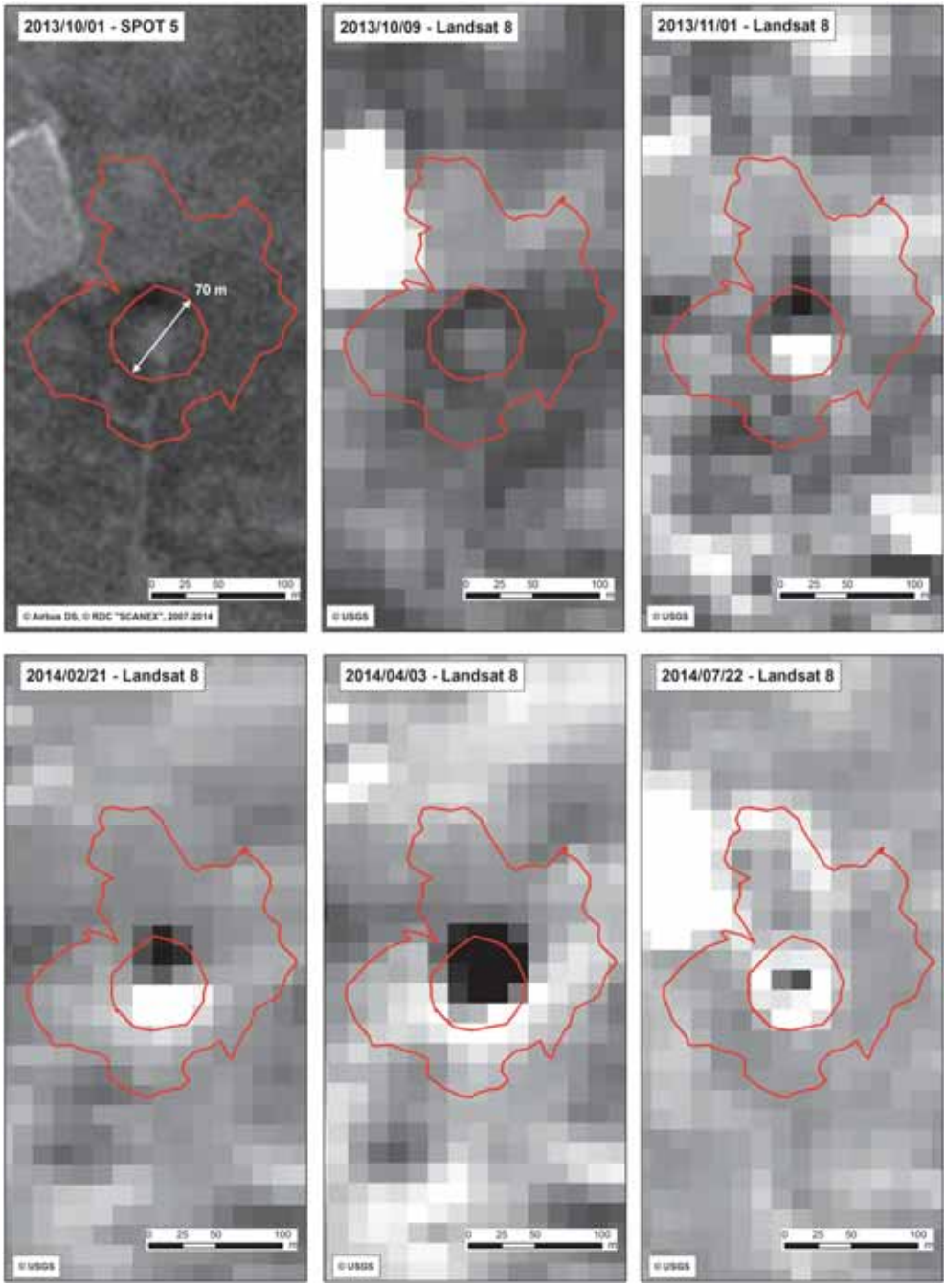

Fig. 8. Time series of SPOT 5 and Landsat 8 images. Red lines outline the parapet (inner circle) and area of ground blocks scattering (outer line).

frozen ground cover. Ground temperature lags behind air temperature, thus the warm summer of 2012 produced an effect on ground temperature a year later, most likely in the fall of 2013.

As gas in upper layers of permafrost is of bacterial origin [Rivkina et al., 2006; Streletskaya et al., 2014], its distribution over entire permafrost area is independent of the presence or absence of gas deposits within

the area [Yakushev et al., 2005]. Thus such a process of gas hydrate expulsion may happen in other permafrost areas with the same favorable for gas hydrate conservation in the past and decomposition in modern times.

The thaw of the permafrost at the top of the hole initiates a process that will expand the hole and form a lake. Possibly, some Yamal lakes formed during the Holocene climatic optimum about 10,000 years ago and previously considered to be thermokarst lakes, formed through an analogous process.

Conclusions

The reconnaissance established the following:

(1) An exciting permafrost feature, a gas-emission crater surrounded by a parapet no more than 30 m in diameter is observed; (2) As water accumulates at the bottom of the hole, the feature has no access to deeper layers and the assumption that deep-seated gas deposits caused the crater is implausible; (3) No traces of human activity in the vicinity of the crater were found, so this phenomenon is of a purely natural origin; (4) The date of the crater's formation is estimated to have been in the late fall of 2013; (5) The high concentration of methane in the hole, which decreases in the vicinity of the hole and is negligible far from the hole, indicates the role of methane in the formation of the crater; (6) No high background radiation and no traces of extremely high temperatures, which would point to a gas explosion or an extraterrestrial object such as a meteorite were observed.

It is highly probable that such landforms will be generated in the future in sui table geological and permafrost conditions. The origin of this crater is attributed to the anomalously warm summer of 2012, the increased ground temperature and amount of unfrozen water in the permafrost, expanding of cryopegs, formation of a pingo-like mound and its outburst due to high pressure produced by gas hydrate decomposition within permafrost. Similar temperature anomalies may increase in number in the future decades, presenting risks for human activities in the region.

Proving the hypothesis presented in the paper would require a full range of field, laboratory and remote-sensing studies.

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ANALYSIS OF WATER POVERTY FOR IREPODUN LOCAL GOVERNMENT AREA (KWARA STATE, NIGERIA)

Abstract. In the wake of a growing concern about the unchecked rise of poverty and the consequences of water scarcity, the relationships between water and poverty form an object of a sprawling literature. This research seeks to study access to rural water supply in Irepodun Local Government Area (LGA), Kwara State. Data were sourced from the 11wards in the LGA. Twenty households were sampled per ward; altogether 220 households were sampled in this study. Access to water was estimated using Water poverty index (WPI) computed after Sullivan and Meigh [2006] using household data; based on 5 sub-components: resources, accessibility, capacity, uses and environment. Resources was seen to be high generally, with highest in Omu Aran ward I (93 %), accessibility was highest in Oro I (71 %), capacity was generally weak (highest score was 43 % in Omu Aran III), uses was highest in Omu Aran II and in Oko, environment was highest in Ipetu-Rore-Aran Orin ward (63 %.).Water poverty index (WPI) was least (47 %) in Oko ward, while the highest (62 %) was obtained at Ipetu-Rore-Aran Orin ward. Only 2 LGAs namely: Oko and Arandun wards are water poor, all other wards have above average scores. However, the seemingly high scores are mainly due to the relatively high mean annual rainfall (MAR) and the efforts of Community Based Associations (CBA) which is typical of Kwara south senatorial districts of Kwara state which has long history of CBAs and Town Unions dating back into about 100years. Hence, there is need for government and public-private intervention in water provision; particularly in Oko and Arandun wards in view of their low capacities and few sources of water as locals will have low capacities to explore alternative sources of water. Conclusively, access to water in Irepodun LGA is appreciably high. However, the challenges of increasing population and urbanization suggest needs for expanding water resources infrastructures in the LGA.

KEY WORDS: Water Poverty, Income Poverty, Accessibility, Capacity, Uses, Environment, Resources

INTRODUCTION

Water poverty index is a combined measure of water availability and access. It is a platform for discussing the twin relationship between poverty and shortage of water. The World Water Assessment Program [WWAP, 2001] sees water poverty as the condition of insufficient water of satisfactory quality to meet human and environmental need. WPI is the similitude of the HDI, it is disaggregate in nature and it is suitable for assessing people's water need, particularly in rural households compared to other indices [Alcamo, et al, 1997, 2000; Sekler, et. al. 1998; Vorosmarty, et. al. 2000; Sullivan, 2002; Lawrence et al, 2002; Soussan and Frans, 2003; etc]. The underlying conceptual framework of the index encompass water availability, access to water, capacity for sustaining access, the use of water and the environmental factors which impact on water quality and the ecology which water sustains. One of the challenges of water planners is how to estimate water need of household objectively.

Access to water has become a human right issue and a descriptor of poverty. There

is a strong link between 'water poverty' and 'income poverty' [Sullivan, 2002]. Poor communities suffer great health burden, due to inadequate water supplies and water management as ill health prevents them from moving out of the poverty cycle and diseases. Indeed, poor household expend a disproportionate part of their income on medical treatment for preventable diseases, such income will not be available for investment and production, little wonder the United Nations MDG canvassed for the provision of potable water as a means of poverty alleviation. A direct relationship exists between poverty and sanitation. Poor households have the heaviest health burden; they frequently live in contaminated and degraded environments where pathogens and toxic chemicals agents are common in water, air and soil. In such environment, services that provide protection for public health, water supply, sanitation and drainage are less developed. In addition, poor people have lower levels of malnutrition; they have likelihood of infectious diseases. The impact of diseases is mostly felt by poor households in the developing world, unlike within the developed world where payment will be made through health insurance or social security; in poor nations safety net is not common. Hence, expenditure on sickness will lead to foregoing other items such as food and education [Soussan and Frans, 2003]. Ill health will lead to loss of time spent on income generation. According to Rennie and Sighn [1996] the poor of the world depend directly on natural resources such as raw water, streams, river basins, etc.

The nexus between domestic water supply and poverty becomes more threatening when we reflect on these facts: first, that almost 2 in 3 people who need safe dirking water survive on less than 2 dollar a day; second, daily women across the world spend some 200 hours collecting water [WaterAid, 2012]; third, children in poor environment carry 1000 parasitic warms in their bodies at any time [Waterfacts, 2011]; fourth, water and sanitation crises have claimed more lives through diseases than any war through weapons [Waterfacts,2012]; lastly, that, yearly, 1.4 million children die from unavailable clean drinking water of which 98 % lives in developing world.

Nigeria has been listed as one of the countries that will be water stressed in the next decade. According to Moll and Molluga, [2008] water scarcity can be in respect of physical scarcity, economic scarcity, management scarcity, institutional scarcity and political scarcity. In the same vein, Ashton [2002; 2007] have also documented cases of water conflicts induced by water scarcity in Nigeria.

A study of WPI will give an insight to the nature of water problems; assist in monitoring progress made at water provision by local authorities and may serve as a whistle blower on the level of water supply. Further, a direct bearing exist between rural water supply and school enrolment, hence, WPI will give insights to school enrolment and especially the extent of girl child education (both in terms of school enrolment and rate of completion of primary school education). The analysis of water poverty in Irepodun Local Government is of relevance in the following respect; it will: (i) assist in evaluating the state of water supply in the LGA, (ii) provide an insight into water management, (iii) expose the gap in developmental processes as it relates to water supply, (iv)guide government and the communities on their roles in self help projects, (v) showcase water use level of people with a view to assisting in decision making processes and development planning, it will indicate the level of vulnerability of the community to conflicts and finally (vi) results can be interpolated to areas where such analysis has not been previously conducted.

This work is aimed at analyzing water accessibility via water poverty index at the household level in Irepodun Local Government area of Kwara State.

STUDY AREA

Nigeria is a federation with 3 tiers of government, which are federal, states and LGAs, Nigeria comprises of 36 states and 774 LGAs. This is to make governance close to the ordinary citizen. Nigeria has a population of 167 million and a landmass of 910,770km^2. Irepodun LGA is one of the 774 LGAs in Nigeria and one the 16 LGAs in Kwara state. Irepodun LGA has an area of 737 km^2 and a population of 148,610 people (2006 census).

According to the data released by the World Bank in 2014, average precipitation in Nigeria is 1,150 mm, the percentage of annual domestic fresh water withdrawal in Nigeria is 31 billion cubic meters, GDP water use is 16 dollar per cubic meters. Also, access to improved water supply in the rural areas in Nigeria is 49 %, while internal renewable fresh water resource is 1,346 cubic meters and access to improved water sources between 2009 and 2013 in Nigeria is 64 %. According to the same report, GDP per capita is 3,010 US Dollar and 84 % of land is under agriculture. Primary school completion rate is 76 % and ratio of boys to girls in school enrolment is 91 % while under five mortality is 124 per 1000 live birth.

Irepodun LGA has an alternating climate of wet and dry seasons; wet season last for six months (April to November) with about 1100–1500 mm of rainfall. Dry season starts in November and last in April. Wet season is accompanied by the south westerly wind which originates from the Atlantic Ocean, while dry season is characterized by harmattan wind, which is a dry wind. The area has savannah vegetation characterized by grasses and trees. Irepodun LGA has undulating hills within the older basement complex rocks the area is drained by short swift flowing streams which are mostly seasonal. River Oshin is the principal drainage line.

METHODS OF STUDY

Accessibility to water was measured using the water poverty index (WPI) method. WPI combines both the physical quantities relating to water availability and the socio-economic factors relating to poverty to produce an indicator that addresses the diverse factors that affect water resource management [WRI, 2006]. The data required in this study include: sources of water supply in the study area, pattern and distribution of water, factors controlling access to water, community participation in water supplies among others. Water Poverty Index (WPI) was measured after Sullivan and Meigh. [2006] using data collected from households, in view of the shortcomings of WPI based on national data. This was done by collecting information on 5 indices, namely: resources, access, capacity, uses and environment.

The information required was obtained through the use of structured questionnaire. Each of these 5 components attracted a total score of 20 %, and will add up to100 %. Hence, any community with a score of less than 50 % may be regarded as water poor. 20 copies of questionnaire were administered per ward; this makes a total of 220 copies in which 220 households were sampled. The primary data were collected from the field (study area) through questionnaires and personal interviews.

The questionnaire is divided into two sections. Section A consists of primary attributes of respondents, while section B comprises of water poverty index components: resources, access, capacity, uses and environment.

WPI value is a number between 0 and 100, where a low score indicates water poverty and a high score indicates good water provision. Each of these component indices is made up of sub-indices. Once all component indices have been calculated, they are added together, producing a value between 0 and 100. This value is the water poverty index [WRI, 2006].

RESULTS

Primary attributes of respondents

According to Table 1, about17.7 % of the respondents are farmers, 25.9 % are civil

servants and 20.5 % are traders. This shows that many of the respondents belong to the informal sector. Also, majority of the respondents had primary school education (37.3 %). While 22.7 % attended secondary school education. Family size will affect the volume of water a household will use. Therefore, the larger the family sizes the more the quantity of water they consume. Family size ranges from 0 to 42.3 % in the study area; family size of 3 -5 members and 6 -10 members were 42.3 % respectively, Suggesting that family sizes in Irepodun L.G.A are generally fairly large. Income of majority of respondents (34.1 %) ranges between N7, 500and N10, 000 and also between less than N7, 500 per month (about33.6 %). These show that income of respondents is relatively low.

Table 1. Distribution of Respondents by Socio-Economic Characteristics.

Occupation of the respondents				
Wards	**Trading**	**Farming**	**Civil Servant**	**Others**
Omu-Aran I	5	2	4	9
Omu-Aran II	7	3	3	7
Omu-Aran III	3	3	7	7
Oro I	7	2	4	7
Oro II	3	2	3	12
Ajaselpo I	3	1	6	10
Ajaselpo II	2	4	5	9
Esie/Ijan	3	2	8	7
Oko	3	8	5	4
Arandun	4	9	4	3
Ipetu/Rore/Aran Orin	5	3	8	4
Total Percentage %	20.5 %	17.7 %	25.9 %	35.9 %

Family Size of the respondents

Wards	**1-2**	**3-5**	**6-10**	**ABOVE 10**
Omu-Aran I	2	6	12	0
Omu-Aran II	0	9	11	0
Omu-Aran III	1	11	8	0
Oro I	1	3	14	2
Oro II	3	6	10	1
Ajaselpo I	0	15	4	1
Ajaselpo II	0	15	4	1
Esie/Ijan	0	9	7	4
Oko	7	3	9	1
Arandun	10	6	4	0
Ipetu/Rore/Aran Orin	0	10	10	0
Total Percentage %	10.9 %	42.3 %	42.3 %	4.5 %

Continue Table 1

Marital status of respondents

Wards	Single	Married	Divorced	Widow/Widower	Others
Omu-Aran I	6	12	0	1	1
Omu-Aran II	6	10	1	1	2
Omu-Aran III	4	9	2	3	2
Wards	**Single**	**Married**	**Divorced**	**Widow/Widower**	**Others**
Oro I	3	10	2	4	1
Oro II	5	9	1	4	1
Ajaselpo I	9	10	0	1	0
Ajaselpo II	6	11	1	1	1
Esie/Ijan	5	11	0	2	2
Oko	8	8	0	2	2
Arandun	4	12	0	2	2
Ipetu/Rore/Aran Orin	4	13	0	2	1
Total Percentage %	27.3 %	52.3 %	3.2 %	10.5 %	6.82 %

Income level per month of respondents

WARDS	LESS THAN ₦7500	₦7,500-₦10,000	₦10,000 -₦15,000	₦15,000-₦20,000	ABOVE ₦20,000
Omu-Aran I	6	6	4	2	2
Omu-Aran II	6	6	2	4	2
Omu-Aran III	5	8	3	0	4
Oro I	3	11	2	2	2
Oro II	7	6	2	0	5
Ajaselpo I	10	5	1	1	3
Ajaselpo II	7	7	3	2	1
Esie/Ijan	5	7	3	4	1
Oko	10	6	1	2	1
Arandun	12	4	2	0	2
Ipetu/Rore/Aran Orin	3	9	3	4	1
Total Percentage %	33.6 %	34.1 %	11.8 %	9.5 %	11.0 %

COMPONENTS OF WATER POVERTY

Water resources

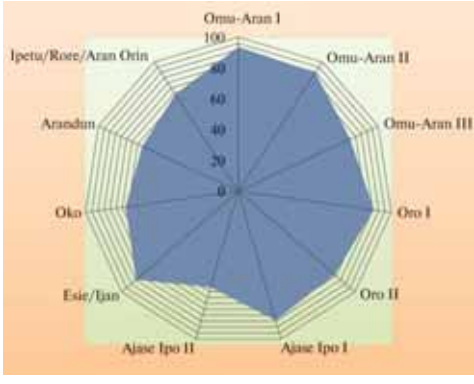
Omu-Aran I is having the highest score (93.75 %), while Ajase-Ipo II has the least resource base (65 %) (Table2.a). This is expected because Omu-Aran I is an LGA headquarter, it has the necessary infrastructure such as: pipe borne water, tarred roads, electricity, General Hospital, schools, etc unlike Ajase-Ipo II which is in the hinterland.

Accessibility to Water Resources

In terms of water resources Esie/ Ijan has the highest advantage having a score of 75 %on access to water. Respondents in this ward have access to multiple sources of water; such as streams, hand dug wells, boreholes and pipe borne water. This ward has benefited from several self help projects in the area of water supply. Besides, most of the streams in this ward are still potable, in view of its relatively low population. Oko

Table 2(a). Water resources

S/N	Wards	Major Source of Water Supply (a)	Alternative Source of Water (b)	Differences Between Surface and Groundwater (c)	Water Supply Quality (d)	Subcomponent	
						(e) (%)	(f) (e/10)
1	Omu-Aran I	20	15	20	20	93.75	9.40
2	Omu-Aran Ii	19	17	17	20	91.75	9.20
3	Omu-Aran Iii	19	15	13	17	80.00	8.00
4	Oro I	18	17	17	19	88.75	8.87
5	Oro Ii	19	13	14	20	82.5	8.25
6	Ajaselpo I	2o	15	15	20	87.5	8.75
7	Ajaselpo Ii	20	6	6	20	65.00	6.50
8	Esie/Ijan	20	15	15	20	87.5	8.75
9	Oko	12	14	17	16	73.75	7.38
10	Arandun	16	8	15	16	68.75	6.88
11	Ipetu/Rore/Aran Orin	19	12	11	18	75.00	7.50



TFig. 2a. Distribution of Resource Per Ward

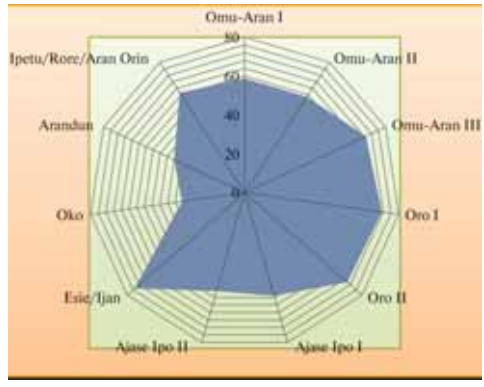


Fig 2b. Pattern of acess to water per ward

Table 2(b). Accessibility to Water Resources

S/N Wards	Access to Piped Water Supply (a)	Conflict Over Water Use (b)	Sanitation (c)	Specific Time in Water Collection (d)	Subcomponent	
					(e) (%)	(f) (e/10)
1.Omu-Aran I	13	6	18	10	58.75	5.88
2.Omu-Aran Ii	14	7	20	6	58.75	5.88
3.Omu-Aran Iii	18	8	15	14	68.75	6.88
4. Oro I	17	12	15	13	71.25	7.13
5.Oro Ii	13	10	14	19	70	7.00
6. Ajase Ipo I	9	11	13	11	55	5.50
7. Ajaselpo Ii	0	16	14	12	52.5	5.25
8. Esie/Ijan	12	12	19	17	75	7.50
9. Oko	1	7	10	8	32.5	3.25
10.Arandun	4	5	15	8	40	4.00
11. Ipetu/Rore/Aran Orin	7	11	14	17	6l.25	6.25

ward remains the least in terms of access; having 32.5 % accessibility to water; it has the least access to sources of water having only hand-pump wells (Table 2b).

Capacity for Empowerment

The score of each ward on capacity is generally weak, with a maximum of 50 % in Ipetu/Rore/Aran-Orin (Table 2c; Figure 2c).

Table 2(c). Capacity for Empowerment

S/N Wards	Illness (a)	Under five (5) Mortality Rate (b)	Educa-tional Level (c)	% of Respondents Receiving Pension or Wages (d)	Subcomponent	
					(e) %	(f) (e/10)
1. Omu-Aran I	3	1	17	12	41.25	4.13
2. Omu-Aran Ii	6	1	20	7	42.50	4.25
3. Omu-Aran Iii	7	0	15	13	43.75	4.37
4. Oro I	7	1	6	6	25.00	2.30
5. Oro Ii	8	0	16	5	36.25	3.63
6. Ajase Ipo I	7	1	17	4	36.25	3.63
7. Ajase Ipo II	8	1	12	4	31.25	3.12
8. Esie/Ijan	8	1	16	6	38.75	3.88
9. Oko	3	0	9	5	21.25	2.12
10. Arandun	2	0	9	4	18.75	1.88
11. Ipetu/Rore/Aran Orin	9	5	18	8	50	5.00

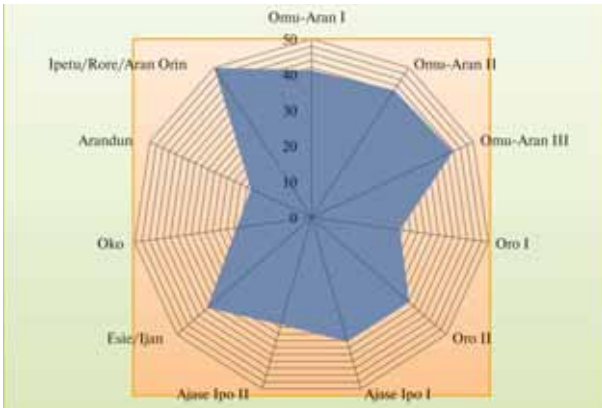


Fig. 2c. Pattern of respondent's capacity per ward

The least is found in Arandun ward with 18.75 % capacity. The occupation dynamics of Ipetu/Rore/Aran-Orin ward is somehow complex, having an appreciable number of business people, civil servants and farmers who are empowered; also the level of income in this ward is the highest ranging between 7,500 to 10,000 naira.

Table 2(d). Water Uses

S/N Wards	Domestic Uses (a)	Industrial Uses (b)	Agricultural Uses (c)	Livestock Uses (d)	Subcomponent	
					(e) (%)	(f) (e/10)
1. Omu-Aran I	20	3	2	16	51.25	5.13
2. Omu-Aran Ii	20	3	8	16	58.75	5.88
3. Omu-Aran Iii	20	2	5	17	55.00	5.50
4. Oro I	20	1	3	13	46.25	4.63
5. Oro Ii	20	1	3	13	46.25	4.63
6. Ajaselpo I	20	1	2	16	48.75	4.88
7. Ajaselpo Ii	20	1	4	16	51.25	5.13
8. Esie/Ijan	20	1	3	19	53.75	5.38
9. Oko	20	9	8	10	58.75	5.90
10. Arandun	20	8	10	12	62.50	6.25
11. Ipetu/Rore/Aran Orin	20	4	8	16	60.00	6.00

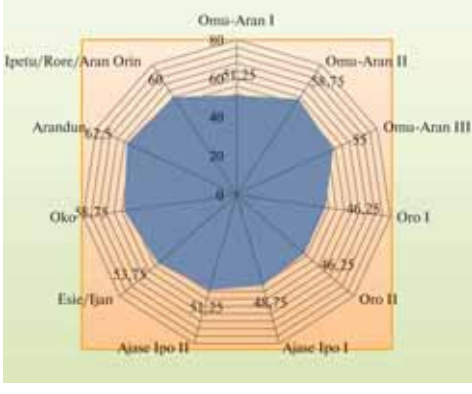


Fig. 2d. Pattern of water use per ward

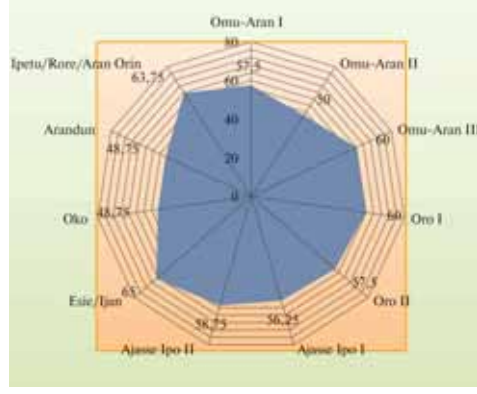


Fig. 2e. Pattern of environmental sub component

Table 2(e). Respondents' Environment

S/N Wards	Pollution (a)	Crop Loss in the Last Five (5) Years (b)	Erosion (c)	Environmental Regulation and Management (d)	Subcomponent	
					(e) (%)	(f) (e/10)
1. Omu-Aran I	14	2	10	20	57.5	5.75
2. Omu-Aranii	4	2	14	20	50.0	5.00
3. Omu-Aran Iii	14	4	10	20	60.0	6.00
4. Oro I	11	1	16	20	60.0	6.00
5. Oro Ii	12	0	11	20	57.5	5.75
6. Ajase Ipo I	13	1	11	20	56.25	5.63
7. Ajase Ipo Ii	16	3	11	17	58.75	5.88
8. Esie/Ijan	17	1	14	20	65.0	6.50
9. Oko	6	8	9	16	48.75	4.87
10. Arandun	7	10	12	16	48.75	4.88
11. Ipetu/Rore/Aran Orin	13	6	13	19	63.75	6.38

Pattern of Water Use

Water in the study area is mainly used for domestic purposes, water use is largely rural. Water related industries such as a few block and sachet water industries can be found. Livestock watering is also common. Arandun ward recorded the highest score in terms of uses with 62.5 %, while Oro I has 46.25 % (Table 2d; Figure 2d). This implies that Arandun ward uses water for other purposes than domestic purposes, such as block making and irrigation agriculture (marketing gardening).

Nature of Respondents' Environment

According to Table 2(e), all the wards are exposed to on environmental problem or the other. Esie/Ijan ward scored 65 %, while Oko and Arandun wards have 48.75 % respectively (Figure 2(e)).

WATER POVERTY INDICES (WPI)

According to Table 3 and Figure 3(a and b), Esie/Ijan ward has the highest WPI, having highest score in resources (87.5 %), access (75 %) and environment (65 %) and WPI of 64 %; suggesting an advantage over others. Oko ward has the least WPI of 47 %, with least scores on access (32.5 %), capacity (21.25 %) and environment (48.75 %).

A comparative analyses of the WPI components show that resources has the highest score in all the communities, while capacity remain the least in all the wards. The high score recorded by resources is expected in view of the relatively high mean annual rainfall of about 1,500mm which produced a minimum length of rainy season of about 6 months. Hence, the area has also benefited immensely from the relatively deep weathering which has provided a regolith aquifer for boreholes in this region. Deep weathering has been discovered in parts of the study. Furthermore, the study area has been at the fore front of self help projects.

PROBLEMS OF WATER SUPPLY

A number of problems are facing water resources development in Irepodun LGA. Some of these are discussed below.

i. Low capacity of water treatment facility in government water works: This is a common problem confronting water supply in Irepodun Local Government, as there is no ward experiencing daily water supply from the State Water Corporation due to the small sizes of treatment plants in the few settlements with public water supply particularly, Oro, Ajase-Ipo and Omu-Aran. This results in water shortages in these towns.

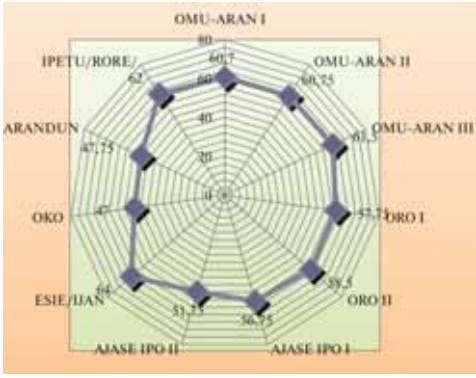


Fig. 3a. Water Poverty Indices (WPI) according to wards

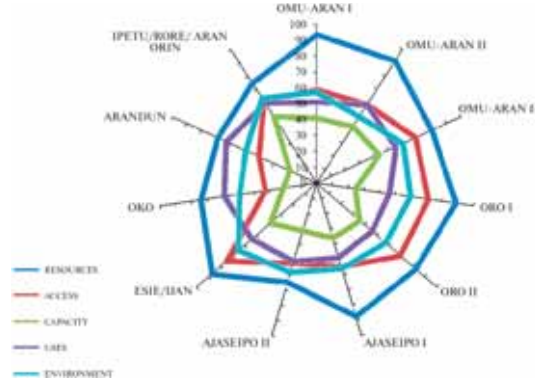


Fig. 3(b): Water Poverty Indices (WPI)

Table 3. Water poverty Indices (WPI)

Wards	Re-sources	Access	Capacity	Uses	Envi-ron-ment	WPI (%)		
						Irepodun LGA	Countries	
Ajase-Ipo I	87.50	55.00	36.25	48.75	56.25	56.75	USA	65.0
Ajase-Ipo II	65.00	52.50	31.25	51.25	58.75	51.75	Sri Lanka	56.2
Arandun	68.75	40.00	18.75	62.50	48.75	47.75	United Kingdom	71.5
Esie/Ijan	87.50	75.00	38.75	53.75	65.00	64.00	Rwanda	39.4
Ipetu/Rore/Aran Orin	75.00	61.25	50.00	60.00	63.75	62.00	Russia	63,.4
Oko	73.75	32.50	21.25	58.75	48.75	47.00	Sweden	72.4
Omu-Aran I	93.75	58.75	41.25	51.25	57.50	60.70	Benin	39.3
Omu-Aran II	91.75	58.75	42.50	58.75	50.00	60.75	Burkina Faso	41.3
Omu-Aran III	80.00	68.75	43.75	55.00	60.00	61.50	Togo	46.0
Oro I	88.75	71.25	25.00	46.25	60.00	57.75	Nigeria	43.9
Oro II	82.50	70.00	36.25	46.25	57.50	58.50	Niger	35.2

ii. Faulty Taps and Pipes: Some of the public water taps in the study area are worn-out due to poor maintenance; hence, water is constantly wasted, especially inOmu-AranWard I and II, Oro I andAjaseIpo II.

iii. Poor Maintenance of Water Infrastructure: Some boreholes are no longer functional for lack of servicing atIpetu/Rore/Aran Orin and Arandun wards.

iv. Power Failure: The problem of power failure affects the process of treatment and water pumping for distribution. This is a common problem in AjaseIpo II, Esie/Ijan and Oro II ward.

v. Long Queue: In places with public water taps, there is the problem of long queue due to high pressure around Ipetu/Rore/ Aran Orin, Omu-Aran I and III, Oro II and Esie/Ijan ward.

DISCUSSION

The wards of the study area have strong scores on resources ranging from 68 % in Arandun to 93 % in Omu-Aran. This suggests

that these communities are endowed. They have more than one source of water. The climate of the study area is humid tropical continental with about 6 months of rainy season, where mean annual rainfall is about 1,500mm. In fact, the LGA has one of the highest MAR in Kwara state, this quantity of rain gives rise to forested vegetation Omu-Aran, Arandun, Ajese-Ipo, Aran-Orin, etc. water sources is another dominant variable. Oro and Esie wards scored 70 and 71 % respectively in this regards. These wards have shorter times of water collection. These communities have several hand pumps and hand dug wells, these wards are also contagious. They also have the highest numbers of community self-help projects in the LGA. They have very strong town development associations whose existence dated over 50 years back. Oko has the least water points because; it has only one water source, which is borehole.

As regards capacity, all the wards have weak scores. This is expected in rural areas in view of the few opportunities which abound. Ipetu/Rore/Aran-orin ward has the highest score on capacity. This ward is renowned for agriculture, particularly vegetable business; it has the highest income range, and has more than one occupation type. Omu_Aran wards which serve as the LGA headquarter also have relatively high capacity. Generally, capacity is weak in the LGA. This is an indication of widespread poverty which is typical of many Nigeria rural communities. This will affect capacities to buy water, for water use and accessibility to water. Only 2 LGAs namely: Oko and Arandun wards can be regarded as water poor, all other wards have above average scores. However, this is not to say that these wards have strong scores. Indeed, water resources in these wards still needed some level of intervention, in view of the fact that these seemingly high scores are mainly due to available resource of the relatively high mean annual rainfall coupled with the efforts of various Community Based Associations (CBA) which is typical of Kwara south senatorial area where existence of some CBAs and Town Unions dated back into about 100 years.Hence, there is need for government and public- private efforts with some of the CBAs in water provision. More importantly there is need for government intervention in Oko and Arandun wards with low capacities and low scores on sources of water, these is because a breakdown or contamination of the singular source of water to these communities will wreck havoc, as locals will have low capacity to explore alternative sources of water.

A comparison of WPI values for Nigeria (43.9 %) with the values obtained in this study for Irepodun LGAs (ranging between 47 % in Oko to 64 % in Esie/Ijan ward) shows that WPI in Irepodun is greater than the national average for Nigeria. In the same vein, a comparison of the values presented by Lawrence, et. al [2002] indicated that WPI value for Nigeria is higher than what obtains in some African countries such as Rwanda, Benin, Burkina Faso, Togo and Niger republic. However, there is still need for improvement on the part of the relevant tiers of government at improving water access in the study area.

CONCLUSION

The results show that resources have the highest value in terms of percentage which means respondents have more than one or two sources of water supply. Also, capacity has least score throughout suggesting that poverty is widespread in the LGA.

However, rural water supply is relatively above average as many of the communities have WPI values above average apart from Oko and Arandun which have values below average. The relatively strong value of WPI is in view of the strong base of resources which manifest in form of relatively high MAR of about 1,600 mm, which translate to 6 months of rainfall, this has made water available and also

in view of the widespread community based efforts in many of communities. Hence, government still needs to double its efforts. However, intervention is required in Oko and Arandun, where WPI are low. These communities have low capacities and fewer sources of water, this is necessary in view of their weak capacity to seek for alternative sources of water, especially in situations of diseases outbreak. ■

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SOCIAL RISK AND VULNERABILITY ASSESSMENT OF HAZARDOUS HYDROLOGICAL PHENOMENA IN THE KRASNODAR REGION OF RUSSIA

ABSTRACT. Methods and results of social vulnerability and risk assessment are presented in the article. It is explored if modified methodology of the United Nations University (World risk index) can be used on different scale levels: regional, municipal and settlement. It was estimated that, despite the low value of the World risk index for Russia, southern coastal and mountain regions have high values of the risk index for hydrological phenomena because of higher frequency of the hazardous events, higher population density, and high social vulnerability. The Krasnodar region (in the south-western part of Russia) was chosen for a detailed analysis. A municipal risk index was developed, and municipal districts in the Kuban river mouth were identified as territories with the highest risk. For verification of the index results, the percentage of vulnerable people was estimated based on opinion polls. The results can be used in further risk calculation for other hazardous phenomena.

Key words: social vulnerability, hazardous hydrological phenomena, risk assessment, Russian regions, coastal areas.

INTRODUCTION

Hydrological phenomena (floods, storm surges, ground water level rise, etc.) are one of the main natural hazards in Russia [Miagkov, 1995; Petrova, 2006; Shoygu et al., 2010; Koronkevich et al., 2010; Gladkevich et al., 2011]. More than 10 million people, or 7.2 per cent of the population, are exposed [Ministry of Finance, 2011], and the area affected by flooding covers over 0.5 million km^2, or 2.9 per cent of Russian territory [Taratunin, 2008]. Meanwhile, natural hazards assessment is quiet developed in Russia, the assessment of flood impact on the socio-economic development is only infrequently considered in publications [Petrova, 2006; Baburin et al., 2009; Gladkevich et al., 2011; Zemtsov et al., 2012]. And the focus in this works is on the assessment of potential economic damage [Baburin et al., 2009], while in the similar studies in other European countries social vulnerability is more often reported [Birkmann 2007; Fekete, 2010; Fuchs et al., 2012, Birkmann et al., 2013]. The main gap for Russian studies from our point of view is a lack of works dedicated to the social vulnerability of regional and local communities.

Social risk denotes as a product of hazardous event occurrence probability and potential social losses (e.g. injuries or destruction of social networks). The primacy of the economic risk assessments persists in the Russian academic and administrative tradition, partly due to the orientation of

the Russian statistics on accounting of the material assets. The nonmaterial parts of the national wealth (people, knowledge, social networks, etc.) are much more difficult to evaluate. However, social losses can be even higher than economic damage of fixed assets and infrastructure [Zemtsov et al., 2013].

The main purpose of the work is to estimate the potential influence of hazardous hydrological phenomena, especially floods, on society, using vulnerability assessment techniques. 'Vulnerability' is a universal category for such purposes, because any territorial system (ecological, technological or social) has its own level of resistance to disaster risk, and vulnerability is "the degree of damage that can be expected depending on the characteristics of an 'element at risk' with respect to a certain hazard" [Fuchs et al., 2011].

The work is based on the methodology, which was developed in the United Nations University Institute for Environment and Human Security (UNU-EHS) and represented in the World Risk Report [World Risk Report, 2011]. Despite the low value of the risk index for Russia (0.0383), the socio-economic risk of hazardous phenomena is unevenly distributed on its territory [Petrova, 2006; Gladkevich et al., 2011]; there are a number of areas with high and very high value of risk and vulnerability. One of the technical hypotheses is that the 'World Risk Index' (WRI) methods can be effectively applied on sub-national and intra-regional levels.

The authors have been able to modify the existing techniques for use at the regional and municipal levels, as well as developed methods of verification and social risk assessment on settlement level.

MATERIALS AND METHODS

The framework of the World Risk Report [World Risk Report, 2011] was applied with some modifications. Due to the framework, the concept of 'risk' [Birkmann, 2007; Damm, 2010; Fuchs et al., 2012] consists of two components. The first component is 'exposure', or the amount of potential losses, and it involves an assessment of exposed area and affected population. The second component, 'vulnerability', is used to assess the system's ability to withstand flooding; it includes 'susceptibility' (evaluation of the system sensitivity to natural environment changes), 'coping capacity' (recovery abilities) and 'adaptive capacity' (ability to adapt to changes in long-term period).

Complex subindices, which evaluated each of the components through several indicators, were used on regional and municipal levels. An algorithm for constructing the integral index included several iterations: database compilation, its transformation to a matrix of normalized indicators, assessment of weights for each indicator, application of the final equation and its verification by correlation analysis.

The authors have assumed universality of identified indicators and its relations in the world index, because the aim of the article was to compare results of the methodology on different levels. We tend to use the same or similar indicators and weights on international (*WRI* – world risk index), regional (*RRIR* – regional risk index of Russia) and municipal (*MRI* – municipal risk index of Krasnodar region) levels, but in the result they were slightly different because of statistical disadvantages and some differences in the factors' influence.

For comparison purposes, the gradations from the 'World Risk Report' also were used for every index. It was presumed that the WRI has the highest values for all indices. But 'extremely high risk index' group of regions were added, because some values in Russia were even greater than evaluated by the WRI.

The data of the Russian Federal State Statistics Service [Russian Federal State Statistical Service, 2012] were used. The study is the result of the model adaptation for the Russian statistics, which is more focused on the account of material assets; social 'abilities' of the community can be assessed mostly indirectly. Databases, consisting of relevant indicators according to the framework (Table 1) for 83 Russian regions and 14 coastal municipalities

of the Krasnodar region in 2010, were created. The databases were integrated into a geographic information system (GIS) for further assessment.

The index of social risk (*R*) and vulnerability index (*Vul*) were calculated using the following equati[1]ons:

$$R = NH \times Exp \times Vul; \quad (1)$$

$$Vul = 0.33(Sus + LCC + LAC), \quad (2)$$

where *NH* represents the natural hazard index [Gladkevich et al., 2011], *Exp* entails the exposure index, *Sus* stands for the susceptibility subindex, *LCC* denotes the lack of the coping capacity subindex and *LAC* represents the lack of adaptive capacity subindex.

Equations of linear scaling ('max-min') were used for normalization [Fekete, 2010].

It is essential to assess 'natural risk' (I_{NH}) on the regional level in Russia because of the great difference in intensity, duration, height and destructive power of hazardous hydrological phenomena in different regions. Russian regions were divided into groups according to a 'flooding hazard index'[1] [Gladkevich et al., 2011].

The proportion of people, affected by flooding [Ministry of Finance, 2011], was multiplied by the subindex of population density, and the obtained index was considered as an 'exposure' component on regional level. Population density was taken into account because of a great difference of the indicator among different Russian regions.

Maps of observed and maximum potential flood areas in the Krasnodar region were developed on the municipal level. Evaluation of potential flood areas was based on the altitude [Zemtsov et al., 2012]. An 'exposure index' for municipal risk index was assigned to a proportion of people living in flood prone areas.

The subindices of vulnerability index, according to the framework (Table 1), consist of several parameters, which were assessed by selected indicators.

$$\begin{aligned} Sus^{reg} &= 0.1425 Sus^{reg}_{water\_source} + \\ &+ 0.1425 Sus^{reg}_{sewage} + \\ &+ 0.145 Sus^{reg}_{fragile\_dwell} + \\ &+ 0.1425 Sus^{reg}_{dependance} + \\ &+ 0.1425 Sus^{reg}_{subsist\_min} + 0.285 Sus^{reg}_{GRP}, \end{aligned} \quad (3)$$

where Sus^{reg} is a susceptibility subindex for the Russian regions; $Sus^{reg}_{water\_source}$ is a subindex of share of buildings without water source; Sus^{reg}_{sewage} is a subindex of share of buildings without sewage system; $Sus^{reg}_{fragile\_dwell}$ is a subindex of share of the population living in fragile dwellings; $Sus^{reg}_{dependance}$ is a subindex of dependency ratio (share of under 15- and over 65 – year-olds in relation to the working population); $Sus^{reg}_{subsist\_min}$ is a subindex of share of population with incomes below subsistence minimum; Sus^{reg}_{GRP} is a subindex of Gross regional product.

$$\begin{aligned} Sus^{mun} &= 0.285 Sus^{mun}_{sanitation} + \\ &+ 0.145 Sus^{mun}_{fragile\_dwell} + \\ &+ 0.1425 Sus^{mun}_{subsist\_min} + \\ &+ 0.1425 Sus^{mun}_{soc\_serv} + \\ &+ 0.285 Sus^{mun}_{own\_goods}, \end{aligned} \quad (4)$$

where Sus^{mun} is a susceptibility subindex for the municipal districts of the Krasnodar region; $Sus^{mun}_{sanitation}$ is a subindex of length of improved sanitation per capita;

[1] Index of hazard = 0.5*(duration of flooding) + 0.2*(maximum depth of flooding) + 0.1*(probability of flooding) + 0.1*(percentage of flooding area) + 0.1*(curve type of water discharge, which is forming riverbed). Curve of water discharge, forming riverbed, determines the danger of channel and floodplain rearrangement

Table 1. Parameters of vulnerability for each level of assessment

	Susceptibility subindex				
	Public infrastructure	**Housing conditions**	**Nutrition**	**Poverty and dependencies**	**Economic capacity**
WRI	28.5 %	–	14.5 %	28.5 %	28.5 %
	Population share without access to improved sanitation. Population share without access to improved sanitation	No (Share of the population living in slums)	Share of the population undernourished	Dependency ratio. Extreme poverty population living with USD 1.25 per day or less (purchasing power parity)	GDP per capita (purchasing power parity). Gini index
RRIR	28.5 %	14.5 %	–	28.5 %	28.5 %
	Share of buildings without water source. Share of buildings without sewage system	Share of the population living in fragile dwellings	No	Dependency ratio (share of under 15- and over 65 – year-olds in relation to the working population). Share of population with incomes below subsistence minimum	Gross regional product (*Index of prices). *Gini index*
MRI	28.5 %	14.5 %	–	28.5 %	28.5 %
	Length of improved water source per capita. Length of improved sanitation per capita	Percentage of inhabitants in fragile dwellings	No	Population share with incomes below the subsistence minimum. *Population share of benefiting from social assistance.* Population share of served by social services at home	Sales of own-produced goods, works and services / people
	Lack of coping capacity subindex (I_{LCC})				
	Government and authorities	**Disaster preparedness**	**Medical services**	**Social networks**	**Material coverage**
WRI	45 %	–	45 %	–	10 %
	Corruption Perception Index. Good governance (Failed States Index)	No	Number of beds per 10000 inhabitants. Number of physicians per 10000 inhabitants	No	Insurances
RRIR	45 %	45 %	–	10 %	
	The ratio of income to expenses. The share of foreign direct investment in assets of the region. *Number of state employees per 1000 people.*	*Subsidies per km of coastline*	Number of beds per 10000 inhabitants. Number of physicians per 10000 inhabitants	No	Social and medical insurances per capita
MRI	45 %	45 %	10 %		
	Unemployment rate. Percentage of own revenues of local budgets	No	*Number of beds per 10000 inhabitants.* Number of physicians per 10000 inhabitants. Share of public order protection groups		Average monthly wages per capita

Continue Table 1

	Lack of adaptive capacity subindex (I_{LAC})				
	Education	**Gender equity**	**Environmental management**	**Adaptation strategies**	**Investment**
WRI	25 %	25 %	25 %	–	25 %
	Adult literacy rate. Combined gross school enrolment	Education gender parity. Share of female representatives in parliament	Water resources. Biodiversity. Forest and agricultural management	No	Public health expenditure. Life expectancy at birth. Private health expenditure
RRIR	20 %	20 %	20 %	20 %	20 %
	Share of people with high education. Share of people without education	Proportion of unemployment rates between female and male	*Water resources*. Share of forest recovery	Diversification of labour market	Private investment per assets. Expenditure budget share of education and science
MRI	0.25	–	25 %	–	50 %
	Share of employed people with high education	No	Observed /Maximum flood area	*Diversification of labour market*	Private investment per capita

Source: World Risk Report (2012). Indicators, excluded after verification, are shown in italics.

$Sus^{mun}_{fragile\_dwell}$ is a subindex of percentage of inhabitants in fragile dwellings; $Sus^{mun}_{subsist\_min}$ is a subindex of population share with incomes below the subsistence minimum; $Sus^{mun}_{soc\_serv}$ is a subindex of population share of served by social services at home; $Sus^{mun}_{own\_goods}$ is a subindex of sales of own-produced goods, works and services per capita.

Susceptibility of a community depends on the state of infrastructure, housing condition, social protection of population and economic potential of the region (Table 1). Water supply and sewage (sanitation) system development was used as an indicator of the infrastructure parameter. Water networks provide access to drinking water while sewage networks regulate the outflow of heavy rainfall and reduce potential damage. Housing conditions is a more important parameter for this particular study than undernourished population, which is not common for all Russian regions; fragile dwellings are more prone to destruction. Socially vulnerable groups, which include elderly people and families with children, are more affected during floods. Extreme poverty was measured as a share of population with incomes below subsistence minimum, which varies from €95 to €270 per month between regions due to climate conditions. Gross regional product (GRP) per capita is an indicator of economically developed and independent regional society. It is highly differentiated throughout Russia; price indices (depended on climate condition) between regions were used for clarification of the indicator.

$$LCC^{reg} = 0.45LCC^{reg}_{foreign\_invest} + \\ + 0.225LCC^{reg}_{beds} + 0.225LCC^{reg}_{physicians} + \\ + 0.1LCC^{reg}_{insur}, \quad (5)$$

where LCC^{reg} is a subindex for lack of coping capacity on regional level; $LCC^{reg}_{foreign\_invest}$ is a subindex of share of foreign direct investment in assets of the region; LCC^{reg}_{beds} is a subindex of number of beds per 10000 inhabitants; $LCC^{reg}_{physicians}$ is a subindex of number of physicians per 10000 inhabitants; LCC^{reg}_{insur} is a subindex of social and medical insurances per capita.

$$LCC^{mun} = 0.225LCC^{mun}_{unempl} + \\ + 0.225LCC^{mun}_{budg\_reven} + 0.225LCC^{mun}_{physician} + \\ + 0.225 \times LCC^{mun}_{publ\_protec} + 0.1 \times LCC^{mun}_{wage}, \quad (6)$$

where LCC^{mun} is a subindex for lack of coping capacity subindex on municipal level; LCC^{mun}_{unempl} is a subindex of unemployment rate; $LCC^{mun}_{budg\_reven}$ is a subindex of percentage of own revenues of local budgets; $LCC^{mun}_{physician}$ is a subindex of number of physicians per 10000 inhabitants; $LCC^{mun}_{publ\_protec}$ is a subindex of share of public order protection groups; LCC^{mun}_{wage} is a subindex of average monthly wages per capita.

Ability to recover (coping capacity) is linked to the efficiency of local authorities, development of health services, social relationships and material prosperity of a community. The following ratios can describe the effectiveness of authorities: ratio of income to expenses, percentage of foreign direct investment in assets, number of state employees per 1,000 people and subsidies per km of coastline. Unemployment rate and percentage of own revenues were used as indicators within the MRI, as well as proportion of participants in volunteer groups for the protection of public order, which was chosen to assess the development of social ties.

$$LAC^{reg} = 0.2LAC^{reg}_{educ} + 0.2LAC^{reg}_{female} + \\ + 0.2LAC^{reg}_{forest} + 0.2LAC^{reg}_{diversif} + \\ + 0.1LAC^{reg}_{invest} + 0.1LAC^{reg}_{educ\_expend}, \quad (7)$$

where LAC^{reg} is a subindex for lack of adaptive capacity on regional level; LAC^{reg}_{educ} is a subindex of share of people without education; LAC^{reg}_{female} is a subindex of proportion of unemployment rates between female and male; LAC^{reg}_{forest} is a subindex of share of forest recovery; $LAC^{reg}_{diversif}$ is a subindex of diversification of labour market; LAC^{reg}_{invest} is a subindex of private investment per fixed assets; $LAC^{reg}_{educ\_expend}$ is a subindex of expenditure budget share of education and science.

$$LAC^{mun} = 0.25LAC^{mun}_{high\_educ} + \\ + 0.25LAC^{mun}_{flood\_infr} + 0.5LAC^{mun}_{invest}, \quad (8)$$

where LAC^{mun} is a subindex for lack of adaptive capacity on municipal level; $LAC^{mun}_{high\_educ}$ is a subindex of share of employed people with high education; $LAC^{mun}_{flood\_infr}$ is a subindex of observed / maximum flood area; LAC^{mun}_{invest} is a subindex of private investment per capita.

Adaptive capacity was estimated by level of education, gender parity, diversification rate of labour market, development of technical systems and investment attractiveness. Gender disparities exist, but they are not varying greatly between regions, except some traditional Muslim societies in the Northern Caucasus. Labour diversity is an important indicator of potential adaptation strategy. It was calculated by the Herfindahl

– Hirschman index (I_{HH}), which can estimate the concentration rate:

$$I_{HH} = S_1^2 + S_2^2 + \ldots + S_n^2, \quad (9)$$

where S_1 represents the proportion of the most common sphere of activity (job); S_2 – the proportion of the next common job; S_n includes the proportion of the last common job. The technical systems capacity was estimated as a proportion between observed (before 2010) and maximum potential (based on the altitude with 0.05 probability) flooding areas. Private investment is an indicator of the attractiveness of the area and its potential for diversification.

Correlation matrixes for the indicators are shown in the tables 2 and 3. Low correlation between an indicator and the vulnerability index (less than 0.15) and between an indicator and vulnerability subindices (less than 0.3) was an important excluding criterion for our final selection (excluded indicators are represented in italics in Table 1).

There were some exceptions for I_{LAC} (diversification of the labour market, private investment per fixed assets, and share of expenditure in the budget for education and science) because of its high value for future adaptation in case of flooding. Several indicators (length of improved water source per capita, population share of benefiting from social assistance, number of beds per 10,000 inhabitants, diversification of labour market) were excluded from the MRI for the same reasons[2].

The purpose of the last stage was to verify the method, using field data, collected in Slavyansk municipal district, which has the highest risk index in Krasnodar region. The area is located on the delta of the Kuban River at a height of 1-2 meters above sea level. Hazardous hydrological phenomena are regular, affecting the economy and threatening the health and lives of people.

Hazardous hydrological phenomena were classified into three groups, according to the degree of danger (j)[3] [Zemtsov et al., 2013]:

1. widespread process of ground water level rise (average probability for most of the settlements is 0.99);

2. flooding due to embankment dams breakage with medium level of danger (0.01);

3. catastrophic flooding after the breakout/ overspill of the Krasnodar reservoir and destruction of earthen dams (0.001).

Exposed population were assessed by areas of flooding and density of population on them, which is more accurate assessment of exposure index in comparison with the MRI. The index of exposure declined from 0.7 to 0.3.

The questionnaire consisted of more than 20 questions about susceptibility and vulnerability of the people. Polls were representative by age and gender, 485 respondents participated in the survey in several local communities (settlements): Achuevo, Anastasievskoe, Prikubanskiy, Zaboyskiy, Urma and Derevyankovka.

Component analysis of the collected data [Fekete, 2010] was conducted to identify the most related and valuable questions (Table 4). According to the answers of the selected questions, the percentage of weakly, less and most vulnerable people was estimated (Table 5). This proportion was called vulnerability index. 41.5 % of the total population in Slavyansk district can be attributed to the group of the most vulnerable. This proportion will be used as an index of social vulnerability (V^5) for medium flooding; the sum of the percentages for most and less vulnerable (57.5 %) will be used as a social vulnerability index for catastrophic flooding.

For further social risk assessment, the authors proposed an equation for financial estimation of social risk. We supposed that

[2] Correlation analysis between indicator and indices can be used with certain limitations due to the small number of cases (14 municipal districts).

[3] Probability of disasters was estimated according to frequency of the disaster in analogue territories.

Table 2. Correlation

		1	2	3	4	5	6	7	9	10	11	12	13
1	Share of the buildings without sewage system	1	0,95	0,17	0,38	0,51	-0,37	-0,21	0,16	-0,07	0,23	0,09	-0,12
2	Share of the buildings without improved water source	0,95	1	0,21	0,45	0,52	-0,45	-0,3	0,19	-0,14	0,19	0,16	-0,17
3	Share of the population living in fragile dwellings	0,17	0,21	1	-0,23	0,17	0,16	0,07	-0,13	0,2	0,38	0,28	-0,06
4	Dependency ratio	0,38	0,45	-0,23	1	0,09	-0,73	-0,46	0,2	-0,11	-0,36	-0,15	-0,24
5	Share of population with incomes below subsistence minimum	0,51	0,52	0,17	0,09	1	-0,36	-0,37	0,03	-0,08	0,27	0,35	0,04
6	Gross regional product	-0,37	-0,45	0,16	-0,73	-0,36	1	0,56	-0,11	0,16	0,33	-0,2	0,08
7	Gini index	-0,21	-0,3	0,07	-0,46	-0,37	0,56	1	-0,26	0,06	0,02	-0,07	0
9	The ratio of income to expenses	0,16	0,19	-0,13	0,2	0,03	-0,11	-0,26	1	0,1	0,1	0,04	0,12
10	The share of foreign direct investment in the fixed assets of the region	-0,07	-0,14	0,2	-0,11	-0,08	0,16	0,06	0,1	1	0,28	0	-0,08
11	Number of government employees per 1000 people	0,23	0,19	0,38	-0,36	0,27	0,33	0,02	0,1	0,28	1	0,07	0,06
12	The cost of subsidies per kilometre of coastline	0,09	0,16	0,28	-0,15	0,35	-0,2	-0,07	0,04	0	0,07	1	0,13
13	Number of hospital beds per 10000 inhabitants	-0,12	-0,17	-0,06	-0,24	0,04	0,08	0	0,12	-0,08	0,06	0,13	1
14	Number of physicians per 10000 inhabitants	0,1	0	0,18	-0,13	0,29	0,02	-0,13	0,16	0,37	0,4	-0,07	0,4
15	Budget of social and medical insurances per capita	-0,29	-0,4	0,32	-0,72	-0,1	0,64	0,35	-0,27	0,31	0,54	-0,16	0,16
17	Share of employed people with high education	-0,33	-0,32	0,1	-0,38	-0,01	0,09	0,13	-0,24	-0,01	0	0,38	0
18	Share of employed people without education	0,1	0,31	0,4	0,25	0,25	-0,35	-0,2	-0,01	-0,2	-0,04	0,44	-0,17
19	Proportion of unemployment rates between female and male	-0,3	-0,27	0,27	-0,38	-0,22	0,22	0,22	-0,12	0,18	0,06	0,2	0
20	Water resources	-0,02	-0,11	0,4	-0,54	0,1	0,35	0,14	-0,03	0,15	0,62	0,11	0,33
21	Share of recovered forest	-0,17	-0,19	-0,08	0,09	0,03	-0,1	-0,16	0,08	-0,06	-0,04	0,29	0,28
22	Diversification of the labour market	0,04	0,1	-0,34	0,28	-0,11	-0,19	-0,19	0,13	-0,22	-0,28	0,01	-0,35
23	Diversification of the GRP structure	-0,26	-0,3	0,19	-0,52	-0,26	0,85	0,4	-0,02	0,23	0,22	-0,09	-0,05
24	Private investment per fixed assets	0,11	0,06	0,15	-0,03	-0,03	-0,01	0,11	0,05	0,17	0,1	0,08	0,01
25	Share of expenditure in the budget for education and science	-0,23	-0,32	0,39	-0,71	-0,09	0,65	0,28	-0,12	0,27	0,63	-0,03	0,12
27	Natural hazard index	-0,21	-0,1	-0,05	-0,03	-0,03	-0,06	0,23	0,08	-0,02	-0,28	0,2	-0,08
29	Exposure index	-0,21	-0,17	0,11	0,06	-0,06	-0,24	0	-0,09	0,16	-0,13	0,38	-0,04
30	Susceptibility index	0,87	0,91	0,37	0,53	0,62	-0,6	-0,26	0,09	-0,07	0,13	0,23	-0,17
31	Lack of coping capacity index	0,12	0,24	-0,05	0,25	0	-0,22	-0,01	-0,25	-0,45	-0,29	0,24	-0,66
32	Lack of adaptive capacity index	-0,12	0	0,2	-0,04	-0,14	0,01	0,09	-0,05	0,04	-0,13	0,09	-0,19
34	Vulnerability index	0,57	0,7	0,28	0,46	0,34	-0,49	-0,14	-0,1	-0,27	-0,11	0,29	-0,51
36	RRIR	-0,19	-0,07	0,19	0,09	-0,01	-0,27	0,02	-0,02	0,02	-0,22	0,5	-0,13

matrix for RRIR

14	15	17	18	19	20	21	22	23	24	25	27	29	30	31	32	34	36
0,1	-0,29	-0,33	0,1	-0,3	-0,02	-0,17	0,04	-0,26	0,11	-0,23	-0,21	-0,21	0,87	0,12	-0,12	0,57	-0,19
0	-0,4	-0,32	0,31	-0,27	-0,11	-0,19	0,1	-0,3	0,06	-0,32	-0,1	-0,17	0,91	0,24	0	0,7	-0,07
0,18	0,32	0,1	0,4	0,27	0,4	-0,08	-0,34	0,19	0,15	0,39	-0,05	0,11	0,37	-0,05	0,2	0,28	0,19
-0,13	-0,72	-0,38	0,25	-0,38	-0,54	0,09	0,28	-0,52	-0,03	-0,71	-0,03	0,06	0,53	0,25	-0,04	0,46	0,09
0,29	-0,1	-0,01	0,25	-0,22	0,1	0,03	-0,11	-0,26	-0,03	-0,09	-0,03	-0,06	0,62	0	-0,14	0,34	-0,01
0,02	0,64	0,09	-0,35	0,22	0,35	-0,1	-0,19	0,85	-0,01	0,65	-0,06	-0,24	-0,6	-0,22	0,01	-0,49	-0,27
-0,13	0,35	0,13	-0,2	0,22	0,14	-0,16	-0,19	0,4	0,11	0,28	0,23	0	-0,26	-0,01	0,09	-0,14	0,02
0,16	-0,27	-0,24	-0,01	-0,12	-0,03	0,08	0,13	-0,02	0,05	-0,12	0,08	-0,09	0,09	-0,25	-0,05	-0,1	-0,02
0,37	0,31	-0,01	-0,2	0,18	0,15	-0,06	-0,22	0,23	0,17	0,27	-0,02	0,16	-0,07	-0,45	0,04	-0,27	0,02
0,4	0,54	0	-0,04	0,06	0,62	-0,04	-0,28	0,22	0,1	0,63	-0,28	-0,13	0,13	-0,29	-0,13	-0,11	-0,22
-0,07	-0,16	0,38	0,44	0,2	0,11	0,29	0,01	-0,09	0,08	-0,03	0,2	0,38	0,23	0,24	0,09	0,29	0,5
0,4	0,16	0	-0,17	0	0,33	0,28	-0,35	-0,05	0,01	0,12	-0,08	-0,04	-0,17	-0,66	-0,19	-0,51	-0,13
1	0,4	-0,29	-0,36	-0,16	0,48	0,02	-0,35	0	0,06	0,39	-0,15	-0,19	0,09	-0,84	-0,3	-0,48	-0,34
0,4	1	0,15	-0,44	0,17	0,63	-0,17	-0,51	0,42	0,08	0,85	-0,23	-0,16	-0,39	-0,5	-0,17	-0,56	-0,3
-0,29	0,15	1	0,15	0,28	0,03	0,22	0,05	-0,04	0	0,19	0,17	0,46	-0,26	0,23	-0,06	-0,07	0,43
-0,36	-0,44	0,15	1	0,2	-0,18	0,07	0,06	-0,18	-0,03	-0,3	0,22	0,27	0,41	0,5	0,45	0,66	0,51
-0,16	0,17	0,28	0,2	1	0,11	-0,04	-0,15	0,13	0,08	0,22	0,33	0,3	-0,24	0,06	0,8	0,14	0,43
0,48	0,63	0,03	-0,18	0,11	1	-0,08	-0,32	0,16	0,3	0,72	-0,24	0,04	-0,08	-0,45	-0,24	-0,36	-0,12
0,02	-0,17	0,22	0,07	-0,04	-0,08	1	-0,07	-0,03	-0,02	-0,11	0,17	0,31	-0,11	-0,04	-0,3	-0,18	0,29
-0,35	-0,51	0,05	0,06	-0,15	-0,32	-0,07	1	-0,05	-0,19	-0,3	-0,02	0,06	-0,02	0,45	0,03	0,23	0,02
0	0,42	-0,04	-0,18	0,13	0,16	-0,03	-0,05	1	0,02	0,46	-0,02	-0,22	-0,43	-0,12	0,05	-0,31	-0,22
0,06	0,08	0	-0,03	0,08	0,3	-0,02	-0,19	0,02	1	0,11	0,02	0,06	0,1	-0,08	-0,21	-0,04	0,06
0,39	0,85	0,19	-0,3	0,22	0,72	-0,11	-0,3	0,46	0,11	1	-0,16	-0,1	-0,34	-0,41	-0,14	-0,48	-0,19
-0,15	-0,23	-0,21	0,22	0,33	-0,24	0,17	-0,02	-0,02	0,02	-0,16	1	0,25	-0,06	0,16	0,31	0,14	0,58
-0,19	-0,16	-0,21	0,27	0,3	0,04	0,31	0,06	-0,22	0,06	-0,1	0,25	1	-0,01	0,19	0,12	0,12	0,85
0,09	-0,39	0,87	0,41	-0,24	-0,08	-0,11	-0,02	-0,43	0,1	-0,34	-0,06	-0,01	1	0,2	0	0,74	0,08
-0,84	-0,5	0,12	0,5	0,06	-0,45	-0,04	0,45	-0,12	-0,08	-0,41	0,16	0,19	0,2	1	0,27	0,73	0,37
-0,3	-0,17	-0,12	0,45	0,8	-0,24	-0,3	0,03	0,05	-0,21	-0,14	0,31	0,12	0	0,27	1	0,47	0,33
-0,48	-0,56	0,57	0,66	0,14	-0,36	-0,18	0,23	-0,31	-0,04	-0,48	0,14	0,12	0,74	0,73	0,47	1	0,34
-0,34	-0,3	-0,19	0,51	0,43	-0,12	0,29	0,02	-0,22	0,06	-0,19	0,58	0,85	0,08	0,37	0,33	0,34	1

Table 3. Correlation

		1	2	3	4	5	6	7	8	9	10
1	Length of water pipe networks	1,00	0,13	-0,20	0,36	-0,37	0,49	-0,46	0,54	-0,53	-0,22
2	Length of sewer system	0,13	1,00	-0,38	-0,31	0,05	0,22	-0,48	-0,20	0,16	-0,05
3	The share of the inhabitants in fragile dwellings	-0,20	-0,38	1,00	-0,01	0,03	-0,14	0,01	-0,06	-0,38	0,09
4	The share of the population with incomes below the subsistence minimum	0,36	-0,31	-0,01	1,00	-0,09	0,57	-0,34	0,61	-0,28	0,18
5	The share of the population benefiting from social assistance to pay for housing services	-0,37	0,05	0,03	-0,09	1,00	-0,41	-0,19	-0,25	0,45	-0,30
6	The share of the population served by the departments of social services at home for senior citizens and disabled	0,49	0,22	-0,14	0,57	-0,41	1,00	-0,52	0,64	-0,44	0,40
7	Sales of own-produced goods, works and services / people	-0,46	-0,48	0,01	-0,34	-0,19	-0,52	1,00	-0,49	0,23	-0,05
8	Unemployment rate	0,54	-0,20	-0,06	0,61	-0,25	0,64	-0,49	1,00	-0,53	0,45
9	The share of own revenues of local budgets	-0,53	0,16	-0,38	-0,28	0,45	-0,44	0,23	-0,53	1,00	0,02
10	Number of hospital beds per 10000 inhabitants	-0,22	-0,05	0,09	0,18	-0,30	0,40	-0,05	0,45	0,02	1,00
11	Number of physicians per 10000 inhabitants	-0,89	0,15	0,00	-0,53	0,45	-0,56	0,46	-0,72	0,64	0,06
12	Share of participants in voluntary groups of population for the protection of public order	0,09	0,69	-0,39	-0,03	0,26	0,02	-0,31	-0,18	0,36	-0,16
13	Average monthly wages per capita	-0,78	-0,13	0,24	-0,55	0,18	-0,65	0,73	-0,77	0,42	0,00
14	Share of employed people with good education	-0,13	0,46	-0,25	0,02	0,59	-0,21	-0,42	-0,20	0,60	-0,20
15	Maximum / Observed flood area	0,33	-0,13	-0,29	0,31	-0,08	-0,02	-0,15	0,13	0,20	-0,18
16	Diversification of the labour market	0,17	0,32	-0,11	-0,10	-0,03	-0,14	0,04	-0,07	0,11	0,01
17	Private investment per people	-0,58	-0,20	0,61	-0,28	0,32	-0,49	0,35	-0,51	0,14	0,03
18	Municipal Risk Index	0,68	-0,05	-0,04	0,30	-0,25	0,31	-0,33	0,19	-0,19	-0,28
19	Exposure	0,63	-0,02	-0,13	0,27	-0,23	0,23	-0,31	0,14	-0,07	-0,27
20	Vulnerability	0,59	-0,20	0,32	0,51	-0,24	0,62	-0,46	0,71	-0,81	0,09
21	Susceptibility	0,11	-0,10	0,40	0,66	0,37	0,46	-0,69	0,49	-0,26	0,19
22	Lack of coping capacity	0,69	-0,40	0,18	0,41	-0,37	0,40	-0,27	0,63	-0,77	-0,16
23	Lack of adaptive capacity	0,32	0,15	0,13	0,03	-0,37	0,47	-0,08	0,33	-0,57	0,24

matrix for MR

11	12	13	14	15	16	17	18	19	20	21	22	23
-0,89	0,09	-0,78	-0,13	0,33	0,17	-0,58	0,68	0,63	0,59	0,11	0,69	0,32
0,15	0,69	-0,13	0,46	-0,13	0,32	-0,20	-0,05	-0,02	-0,20	-0,10	-0,40	0,15
0,00	-0,39	0,24	-0,25	-0,29	-0,11	0,61	-0,04	-0,13	0,32	0,40	0,18	0,13
-0,53	-0,03	-0,55	0,02	0,31	-0,10	-0,28	0,30	0,27	0,51	0,66	0,41	0,03
0,45	0,26	0,18	0,59	-0,08	-0,03	0,32	-0,25	-0,23	-0,24	0,37	-0,37	-0,37
-0,56	0,02	-0,65	-0,21	-0,02	-0,14	-0,49	0,31	0,23	0,62	0,46	0,40	0,47
0,46	-0,31	0,73	-0,42	-0,15	0,04	0,35	-0,33	-0,31	-0,46	-0,69	-0,27	-0,08
-0,72	-0,18	-0,77	-0,20	0,13	-0,07	-0,51	0,19	0,14	0,71	0,49	0,63	0,33
0,64	0,36	0,42	0,60	0,20	0,11	0,14	-0,19	-0,07	-0,81	-0,26	-0,77	-0,57
0,06	-0,16	0,00	-0,20	-0,18	0,01	0,03	-0,28	-0,27	0,09	0,19	-0,16	0,24
1,00	0,15	0,85	0,23	-0,30	0,02	0,61	-0,66	-0,59	-0,77	-0,30	-0,86	-0,34
0,15	1,00	-0,02	0,77	-0,04	0,63	-0,08	-0,28	-0,23	-0,36	-0,02	-0,57	-0,06
0,85	-0,02	1,00	-0,08	-0,30	0,08	0,79	-0,61	-0,55	-0,71	-0,46	-0,69	-0,28
0,23	0,77	-0,08	1,00	0,08	0,41	-0,10	-0,14	-0,09	-0,35	0,22	-0,51	-0,30
-0,30	-0,04	-0,30	0,08	1,00	-0,38	-0,15	0,58	0,72	-0,21	0,01	0,22	-0,72
0,02	0,63	0,08	0,41	-0,38	1,00	-0,07	-0,29	-0,32	-0,11	-0,23	-0,34	0,38
0,61	-0,08	0,79	-0,10	-0,15	-0,07	1,00	-0,43	-0,39	-0,41	0,04	-0,45	-0,35
-0,66	-0,28	-0,61	-0,14	0,58	-0,29	-0,43	1,00	0,98	0,40	0,15	0,63	-0,05
-0,59	-0,23	-0,55	-0,09	0,72	-0,32	-0,39	0,98	1,00	0,24	0,08	0,54	-0,21
-0,77	-0,36	-0,71	-0,35	-0,21	-0,11	-0,41	0,40	0,24	1,00	0,57	0,83	0,65
-0,30	-0,02	-0,46	0,22	0,01	-0,23	0,04	0,15	0,08	0,57	1,00	0,28	0,03
-0,86	-0,57	-0,69	-0,51	0,22	-0,34	-0,45	0,63	0,54	0,83	0,28	1,00	0,31
-0,34	-0,06	-0,28	-0,30	-0,72	0,38	-0,35	-0,05	-0,21	0,65	0,03	0,31	1,00

Table 4. The combination of answers for groups of people with different value of vulnerability

	The most vulnerable	Less vulnerable	The least vulnerable
Can you provide the safety of your life?	No	In part. Do not know	Yes
What is your age?	0–16; >66	56–65	>16; <56
How many years do you live in the area?	Less than 1; 1–5	5–20	> 20
Did you experience flood?	No	Once	More than once

Table 5. The distribution of the vulnerability groups

	Frequency	Per cent	Valid per cent	Cumulative per cent
The most vulnerable	192	40.5	41.5	**41.5**
Less vulnerable	74	15.6	16.0	**57.5**
The least vulnerable	197	41.6	42.5	100
Total	463	97.7	100	

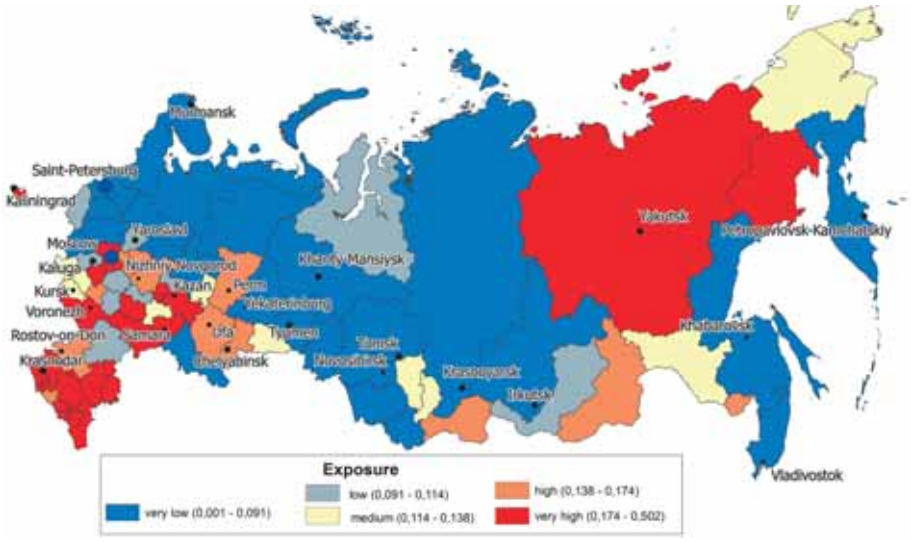

Fig. 1. Exposure index distribution in Russia in 2010

social risk can be divided into two categories: 'victims', who are potential victims injured during a flooding, and 'lost' people, who are potential victims killed during an event.

$$D_L^{Social} = \sum_{i,j}\left(E_{ij} \times V_{ij} \times V_{ij}^{Victims} coeff_L^{Victims}\right) + \\ + \sum_{i,j}\left(E_{ij} \times V_{ij} \times V_{ij}^{Lost} \times coeff_L^{Lost}\right), \quad (10)$$

where L is an approach for financial estimation: L_1 is proposed by the authors and L_2 is used by EMERCOM; E is a number of exposed people in a settlement i, according to the degree of danger (j); $V^{(5)}$ is the social vulnerability index (in shares); $V^{Victims}$ is the 'normative' share of 'victims' (0.02 if j=2 (medium flooding) or 0.05 if j=3 (catastrophic) [EMERCOM, 2007]); $coeff^{Victims}$ is an indicator of an average health losses per one person[4]; V^{Lost} is the 'normative' death rate (0.05 if j=2; 0.1 if j=3 [EMERCOM, 2007]); $coeff^{Lost}$ is a financial estimation of a statistical life loss value[5]. The proposed method can be called as a "real loss for society", because it corresponds to all direct (e.g. lost possible future profits, taxes, etc.) and indirect (e.g. previous education and health expenditure, future demographic losses, etc.) losses in financial terms[6] in comparison with EMERCOM method, which is only used for family compensation issues.

RESULTS AND DISCUSSION

Regional risk index of Russia

Overall exposure subindex within the WRI for Russia is 0.094, but most of the territories have a very low exposure index value (Fig. 1). The lowest exposure values are typically found in regions with the lowest population density (except Magadan region and Republic of Saha); the opposite is true for the Northern Caucasus regions.

The susceptibility index (Fig. 2) within the RRIR is much higher than it is within the WRI (0.21), and comparison between them is impossible because of the lack of the 'nutrition'

[4] L_1 is a share of an average health insurance coverage in the USA, adjusted for gross domestic product difference between the USA and Russia (≈€ 5,000 per capita, Guriev 2010), and L_2 is an average free medical insurance coverage for dismemberment in Russia (≈€ 1,200 per capita).

[5] L_1 is an average value of life insurances in the USA, adjusted for gross domestic product difference between the USA and Russia (≈€1.5m per life lost [Guriev 2010]), and L_2 is the loss of a family with respect to the primary earner (≈€ 50,000 per life lost [EMERCOM 2007]).

[6] Monetization of life loss is debatable issue in literature [Mrozek & Taylor 2002; Viscusi & Aldy 2003], but it is one of the most reasonable approaches for comparing economic and social risks. The best way to assess anyone's value of life is only through his own assessment, which can be expressed as life and medical insurance [Guriev 2009]. If life insurance is common in society, it is hard for government or business to ignore safety rules.

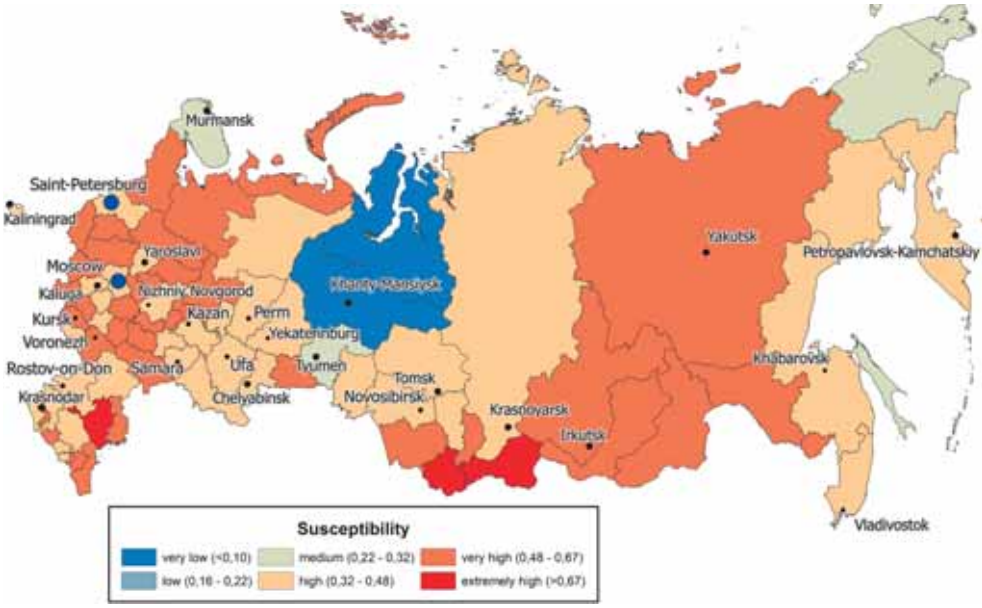

Fig. 2. Susceptibility subindex distribution in Russia in 2010

parameter. It is much less distributed than the exposure index: only most economically and socially developed Moscow, Saint-Petersburg, oil-production Khanti-Mansiysky and Yamalo-Nenetsky regions and three of the most underdeveloped (the Republic of Tyva, the Republic of Altay, and the Republic of Kalmikiya) were allocated. Most of the regions have a high and very high rate of the susceptibility subindex.

Low and medium values prevail in the lack of the coping capacity subindex (Fig. 3), and it coincides with its WRI value (0.597). Far eastern regions have the lowest values because of higher investment and higher indicators per capita.

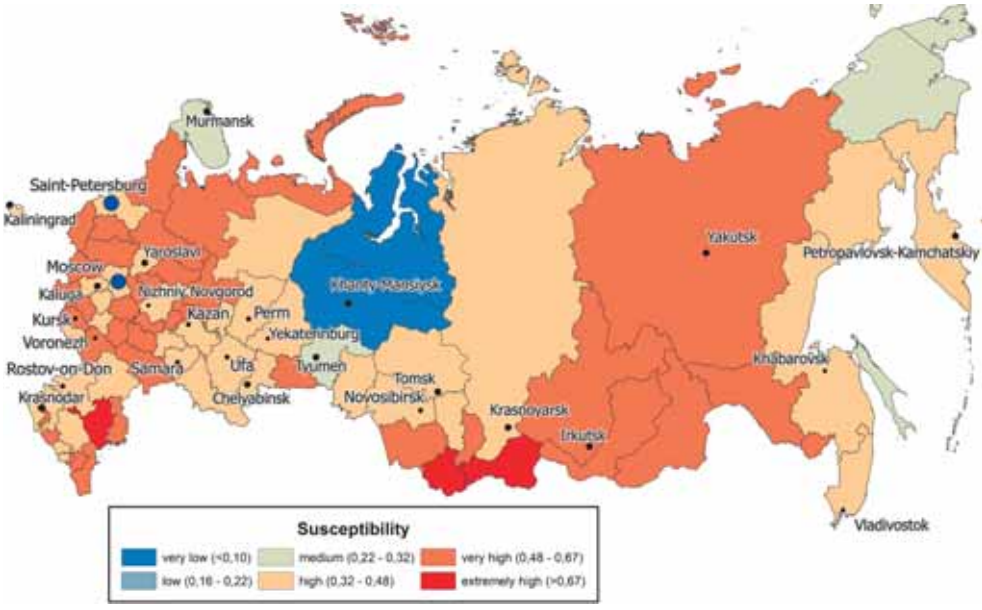

Fig. 3. Lack of coping capacity subindex distribution in Russia in 2010

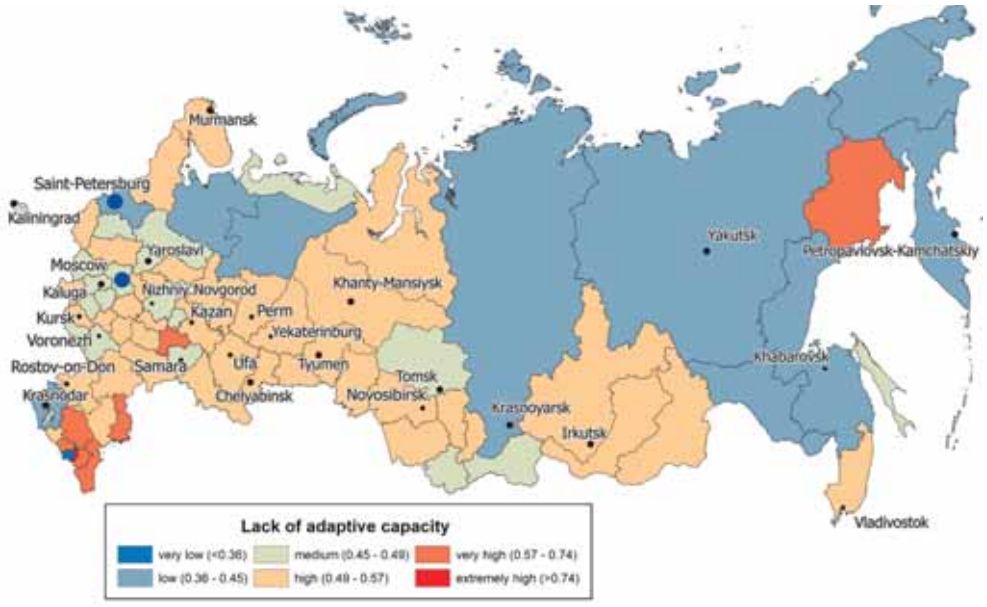

Fig. 4. Lack of adaptive capacity subindex distribution in Russia in 2010

The lack of the adaptive capacity subindex is the most regionally variable component. The lowest values are in the North (Fig. 4) because of the high rate of investment activity and tolerance. In traditional regions of southern Russia, the values are higher. The WRI value is 0.42.

The vulnerability index of Russia within the WRI is approximately 0.41 (Fig. 5). The high value of the index is the most common.

Most of the regions have a very low value of the RRIR (Fig. 6), except several southern territories. Southern coastal and mountain regions have the highest risk index because of their higher population densities, concentrations in river valleys and estuaries

Fig. 5. Vulnerability index distribution in Russia in 2010

Fig. 6. Regional Risk Index of Russia in 2010

and higher social vulnerability in most of the cases. The highest risk values are common for Krasnodar, Saratov regions, the republic of Dagestan, the republic of Northern Ossetia and the republic of Kabardino-Balkaria.

Two versions of the RRIR, before and after exclusion of some indicators due to correlation analysis, were compared. The coefficient of correlation between two versions of the RRIR is 0.99. The index is stable, which can be interpreted as a form of verification.

Krasnodar municipal risk index

Krasnodar region was chosen for a more detailed analysis as one of the regions with the highest RRIR (0.12). The region, especially its coastal zone, is one of the most exposed to hazardous hydrological phenomena in Russia. The research was devoted to a social risk assessment of coastal municipalities of Krasnodar Region. Due to their unique geographical position, coastal areas have a higher concentration of hazards; however, since they can perform a variety of functions, they have a higher concentration of population and economic activity.

Potential flooding and observed flooding areas are shown on Fig. 7. Further approbation of the method shows the highest risk index in coastal municipalities along the mouth of the Kuban River (Fig. 8).

The groups with the lowest index (0.02 to 0.05) are located in highly developed areas and urban districts of the southern coast of the Krasnodar region. The potential damage of hydrological events in the region is related to high intensity and high velocity of water flow. If data on hazards were available, these territories might have a higher index. The foothills and mountainous area have lower populations and the area is less prone to flooding; they also have rather low values of vulnerability, which is associated with well-developed coping capacities. Large cities (Sochi, Novorossiysk, Gelendzhik, Tuapse) in this area have the necessary infrastructure (e.g. health services), economic potential (e.g. high budget revenues and wages) and social ties for the prevention and elimination of consequences of natural disasters.

"Middle" index municipalities are located in areas that have larger flood areas than

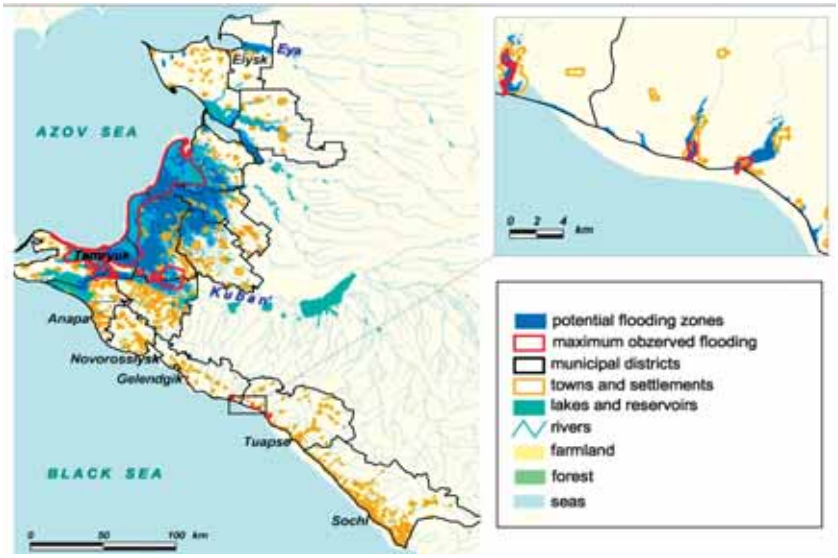

Fig. 7. Potential and maximum observed flooding zones on municipal level of Krasnodar region in 2010

the previous group and also have a high level of vulnerability. The area is located between the delta of the Kuban River and the northern part of the Caucasus.

Areas with the highest index are both the most exposed and the most vulnerable to flooding. Floods can cover large areas and have long durations. The flatland areas, located in the delta of the Kuban, are mainly utilized for agriculture. For the rural plains, single level buildings near the river are typical complicating the ability to adapt to the consequences of floods. The Krymsk district is one of the most vulnerable ones as the area has one of the highest indices of sensitivity, which is associated with a high proportion of socially disadvantaged groups. The coping capacity of regions is generally low due to the low economic potential. Socio-economic system of Temryuk district, due to the high volume of private investment in port infrastructure, intended to increase the degree of economy diversification.

Correlation between two integral indices (before and after exclusion of indicators) is approximately 0.97.

Field-based technique of social vulnerability assessment

During the last stage, the main objective was an evaluation of social vulnerability and potential social damage for the Slavyansk municipal district with the highest risk rate, using the 'field' data.

The social vulnerability index for the Slavyansk municipal district (0.58), based on opinion polls, corresponds to the MRI (0.59). For purpose of verification, the social vulnerability index for each settlement was compared with the percentage of positive answers for several questions and arithmetic mean between them (Fig. 9). Most of the citizens are unaware and are not prepared for flooding events.

Potential social damage was financially estimated (Table 6). The total social damage for a 'middle' scenario is about 11.1 million euro and 272 million euro – for catastrophic scenarios. Economic damage according to the preliminary authors' results [Zemtsov et al., 2013] is about 4.3 million euro in a 'medium' scenario and 142 million euro in

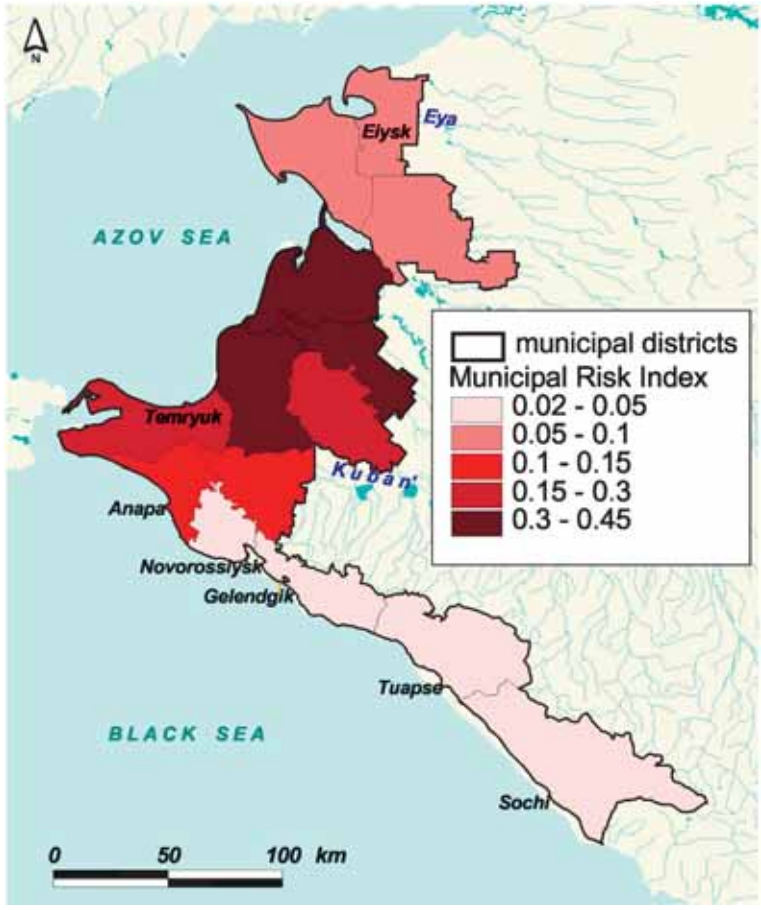

Fig. 8. Municipal Risk Index of Krasnodar region in 2010

catastrophic. In our case, social losses from death and health problems can be similar or even higher than economic damage. This is the main reason for developing a system of protection, warning and evacuation more accurately.

CONCLUSION

Despite of all the difficulties connected with data collection, the discussed method can be used for vulnerability and risk assessments on different scale levels. If the methodology of the WRI was based on known maximum and minimum indicators (like the Human Development Index), it could become a much more useful instrument. A comparison between the integral indices at different levels is possible, but with a number of known limitations. For instance, indicators for normalization (maximum and minimum value) were chosen for each level separately. The similar indicators may have a different meaning on different scale level. The same weights, used on every level for comparison reasons, is debatable.

It is also important to mention that our work were dedicated for risk assessment in 2010, and it is not possible to forecast or use the results for previous periods. The indicators of infrastructure are quite stable in time in contrast to social and economic indicators, which can change greatly during one year. But the presence of many indicators is an advantage of the integral indices; they will

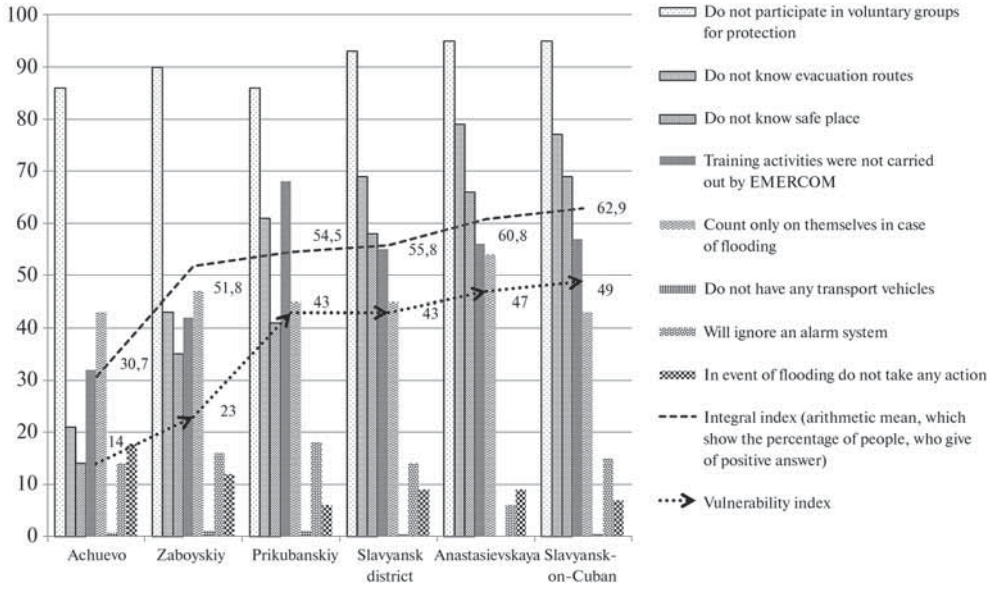

Fig. 9. Percentage of respondents by answers in settlements of Slavyansk municipal district, %

Table 6. Social risk calculations

		Medium flooding	Catastrophic flooding
Potential social loses (persons)	Exposed population	16481	60575
	Vulnerable people	6922	35134
	Victims	138	1757
	Deaths	7	176
Real loss for society (1000 €)	Victims	690	8785
	Deaths	10 500	264 000
	Total potential damage	11 190	272 785
	Annual social risk	111,9	272,8
Government estimation (1000 €)	Victims	165,6	2108,4
	Deaths	350	8800
	Total potential damage	515,6	10 908,40
	Annual social risk	5156	10,91

not be highly changed because of the low influence of each indicator on the final index.

The results of the first stage of the work (Regional Risk index of Russia (RRIR) assessment) are important for regional politics. It highlights the existing problem areas in terms of natural and socio-economic risks.

Most of the territories in Russia have a very low exposure index, which cannot be interpreted as a direct positive fact because of high difference of natural hazards on intraregional level. The highest exposure values are typically found in regions with high flooding hazards (mountain and permafrost territories) and with the highest population density (including Central, Privolzhskiy, Southern and Northern Caucasus federal districts).

Most of the Russian regions have high and very high rates of the susceptibility subindex in comparison with other countries, which is not surprising because of low value of economic development. The subindex is only low for the richest Moscow, Saint-Petersburg, oil-production Khanti-Mansiysky and Yamalo-Nenetsky regions. Fortunately, low and medium values prevail in the lack of the coping capacity subindex, which can be interpreted as a result of a good system of preparedness. The highest rates are common for the least developed Northern Caucasus regions. The lack of the adaptive capacity subindex is high for most regions, which is connected with low investment activity and social diversification. As a result, most of Russian regions have high and very high rates of vulnerability, except the most developed (Moscow, Saint Petersburg and Kaluga region) and oil and mining less populated regions. That is why any natural disaster event can become a social catastrophe in Russia.

Most of the regions have a low value of the integral risk index. Southern coastal and mountain regions have the highest risk index because of their higher population densities, concentrations in river valleys and estuaries and higher social vulnerability in most of the cases. The highest risk values are common for Krasnodar, Saratov regions, the republic of Dagestan, the republic of Northern Ossetia and the republic of Kabardino-Balkaria.

On the second stage, the policy priorities of EMERCOM for improving the protection of citizens and their property in Krasnodar region have been determined. However, the approach cannot be applied to calculate real damages, and overestimation of the index approach is dangerous. Indices can smooth out many disparities and hide real problems. The disadvantage of the approach is the dependence on existing statistics.

Both external (MRI) and internal (component analysis of opinion polls) techniques can quite accurately determine the value of vulnerability for local communities, but the second approach is preferred for risk assessment. Conducted field research allowed identifying the lacking knowledge of the population with regard to hazardous hydrological phenomena.

One of the important results of the work was an estimation of economic and social risks in equivalent measures. Our calculations show that social risk can be higher even in financial values. Social risks can be underestimated in comparison with economic risks due to low 'value of life', which in turn will continue to negatively affect the vulnerability and especially, coping capacity in Russia, because of lesser attention of local authorities to the protection of citizens.

Acknowledgement

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ISSUES OF SUSTAINABLE DEVELOPMENT OF TERRITORIES AT THE BAKU MEETING

On September 16-20, 2014, Baku (Azerbaijan) hosted a meeting of the XVII Joint Scientific Council on Fundamental Geographical Problems of the International Association of Academies of Sciences (IAAS) and the Scientific Council on Fundamental Geographical Problems of the Russian Academy of Sciences (RAS). Such meetings are held annually. The meeting in Baku was devoted to geographic problems of the Caspian Sea region and ways to achieve sustainable development of territories. The Institute of Geography of the Azerbaijan National Academy of Sciences (ANAS) named after its member H. Aliyev, contributed greatly to the organization of the meeting. The meeting included seven sessions.

The first presenter was member of ANAS R.M. Mamedov; his report "Climate change and anthropogenic impacts on the Caspian Sea ecosystem" analyzed the current environmental situation, climatic changes, modern anthropogenic impacts on the ecosystems, and integrated monitoring of the Caspian Sea region. Corresponding member of RAS S.A. Dobrolyubov et al. discussed an integrated electronic atlas of the Caspian Sea. The presentation summed up the results of comprehensive research in the region, which has been conducted over the last half-century by a team of geographers from M.V. Lomonosov Moscow State University (MSU). The atlas consists of maps pertaining to the history of research in the Caspian Sea region, hydrometeorological conditions, geomorphology, and landscape; the maps contain up-to-date socio-economic data and forecast for the regional development in the nearest decades. F.A. Kadyrov and A.A. Feyzullaev (Institute of Geography, ANAS) presented a geodynamic model of the hydrocarbon potential for the South Caspian basin.

The report by corresponding member of ANAS E.K. Alizade et al. (Institute of Geography, ANAS) analyzed landscape and ecological features of geosystems of the west coast of the Caspian Sea and the results of detailed landscape-geochemical mapping. D.V. Desinov et al. (Institute of Geography, RAS) presented strong evidence for feasibility of the use of international space stations for monitoring of oil pollution of the Caspian Sea region. Member of RAS V.A. Rumyantsev (Institute of Limnology, RAS) discussed the Caspian Sea region in his presentation "Blooming blue-green algae – a global social and environmental problem."

A report by N.I. Koronkevich et al. (Institute of Geography, RAS) "Factors that affect the Volga River inflow into the Caspian Sea "summarized the results of long-term hydrological research in the Volga River basin and discussed inter-annual variability and long-term water flow into the Caspian Sea. F.A. Imamov (Baku State University) spoke about the natural and anthropogenic transformation of the annual flow of the Kura River. A.V. Izmaylova (Institute of Limnology, RAS) discussed the role of large and small lakes in the development of territories, using the Caspian Sea region as an example.

A.I. Chistobaev et al. (Research Institute of Spatial Planning "ENKO," Russia) and V. Sefihanly (Company R.I.S.K., Republic of Azerbaijan) analyzed territorial planning of the foothill regions of Azerbaijan. O.B. Glezer (Institute of Geography, RAS) and S.G. Safronova (MSU) presented "The territorial population structure and prospects of modernization in the Caucasus region."

R.G .Gracheva and Yu.P. Badenkov (Institute of Geography, RAS) spoke about the current state and prospects of the pan-Caucasian scientific collaboration.

A.A. Tishkov and E.A. Belanovsky (Institute of Geography, RAS) discussed strategies for the conservation of biological and landscape diversity of the northern coast of the Caspian Sea. A.N. Barmin (Astrakhan State University) presented "The dynamics of the environmental features of land cover of the Volga River delta as a function of climate change." Corresponding member of RAS V.A. Snytko (S.I. Vavilov Institute for the History of Science and Technology, RAS) talked about the historical timeline of scientific research in the Caspian region in the 1930s, using the Lower Volga expedition of the Academy of Sciences of the USSR as an example.

A special session was devoted to achieving sustainable development of territories beyond the Caspian region. Thus, the report by scientists from the Institute for Natural Resources Management (National Academy of Sciences, Belarus [NASB]) V.F. Loginov (member of NASB), B M.I. Struk, and V.S. Homich discussed sustainable territorial development of Belarus. Corresponding member of RAS A.A. Chibilev et al. (Institute of Steppe, Ural Branch RAS) spoke about the Ural basin as a transboundary region and its sustainable development. Corresponding member of RAS B.A. Voronov (Institute for Water and Environmental Problems, Far East Branch, RAS) talked about some aspects of environmental policy for sustainable development of the Russian Far East. "Geographic vectors of sustainable development of Siberia" was presented by L.A. Bezrukov, L.M. Korytny, and V.M. Plyusnin (V.B. Sochava Institute of Geography, Siberian Branch [SB] RAS). Features of sustainable development of mountain regions in transboundary conditions (Altai case study) were discussed by Yu.I. Vinokurov and B.A. Krasnoyarova (Institute for Water and Environmental Problems, SB RAS).

Overall, the meeting covered a wide range of physico-, economico-, and socio-geographic problems related to the Caspian region, as well as sustainable development of Eurasian territories of various geographic dimensions.

The Azerbaijanian geographers organized field trips for the meeting participants to the north-eastern slope of the Greater Caucasus and the Azerbaijanian coast of the Caspian Sea.

Sergei .A. Dobrolyubov,
Valerian A. Snytko

INSTRUCTIONS FOR AUTHORS CONTRIBUTING TO "GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY"

AIMS AND SCOPE OF THE JOURNAL

The scientific English language journal "GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY" aims at informing and covering the results of research and global achievements in the sphere of geography, environmental conservation and sustainable development in the changing world. Publications of the journal are aimed at foreign and Russian scientists – geographers, ecologists, specialists in environmental conservation, natural resource use, education for sustainable development, GIS technology, cartography, social and political geography etc. Publications that are interdisciplinary, theoretical and methodological are particularly welcome, as well as those dealing with field studies in the sphere of environmental science.

Among the main thematic sections of the journal there are basics of geography and environmental science; fundamentals of sustainable development; environmental management; environment and natural resources; human (economic and social) geography; global and regional environmental and climate change; environmental regional planning; sustainable regional development; applied geographical and environmental studies; geo-informatics and environmental mapping; oil and gas exploration and environmental problems; nature conservation and biodiversity; environment and health; education for sustainable development.

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1. Authors are encouraged to submit high-quality, original work: scientific papers according to the scope of the Journal, reviews (only solicited) and brief articles. Earlier published materials are accepted under the decision of the Editorial Board.

2. Papers are accepted in English. Either British or American English spelling and punctuation may be used. Papers in French are accepted under the decision of the Editorial Board.

3. All authors of an article are asked to indicate their **names** (with one forename in full for each author, other forenames being given as initials followed by the surname) and the name and full postal address (including postal code) of the **establishment(s)** where the work was done. If there is more than one institution involved in the work, authors' names should be linked to the appropriate institutions by the use of 1, 2, 3 etc superscript. **Telephone and fax numbers and e-mail addresses** of the authors could be published as well. One author should be identified as a **Corresponding Author**. The e-mail address of the corresponding author will be published, unless requested otherwise.

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5. The optimum size of a manuscript is about 3 000–5 000 words. Under the decision (or request) of the Editorial Board methodological and problem articles or reviews up to 8 000–10 000 words long can be accepted.

6. To facilitate the editorial assessment and reviewing process authors should submit "full" electronic version of their manuscript with embedded figures of "screen" quality as a **.pdf file.**

7. We encourage authors to list three potential expert reviewers in their field. The Editorial Board will view these names as suggestions only. All papers are reviewed by at least two reviewers selected from names suggested by authors, a list of reviewers maintained by GES, and other experts identified by the associate editors. Names of the selected reviewers are not disclosed to authors. The reviewers' comments are sent to authors for consideration.

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Before preparing papers, authors should consult a current issue of the journal at http://www.geogr.msu.ru/GESJournal/index.php to make themselves familiar with the general format, layout of tables, citation of references etc.

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