RUSSIAN GEOGRAPHICAL SOCIETY

FACULTY OF GEOGRAPHY,
LOMONOSOV MOSCOW STATE UNIVERSITY

INSTITUTE OF GEOGRAPHY,
RUSSIAN ACADEMY OF SCIENCES

No. 04 (v. 09)
2016

GEOGRAPHY ENVIRONMENT SUSTAINABILITY

EDITORIAL BOARD

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DOI: 10.15356/2071-9388_04v09_2016_01

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GEOGRAPHICAL AND SOCIO-ECONOMIC PROBLEMS OF NORTH-AFRICAN MIGRATION TO ITALY

ABSTRACT. Differences between countries are explained by a multiplicity of factors that are decisive as the common culture. In particular, the Mediterranean Sea, is a symbolic meeting place between very different cultures. Among the countries that overlook the Mediterranean see of this special attention can be given to cultural differences between Italy and the countries of North Africa (Egypt, Libya and the Maghreb countries like Morocco, Algeria and Tunisia). The proximity geography and contemporary socio - political events require an analysis of the socio - economic interactions between North African and Italian communities.

KEY WORDS: North Africa, Italy, geographical issues, socio-economic problems

INTRODUCTION

The peculiar features which distinguish the countries have ancient roots, the basis of which the mechanisms that allow different cultures to maintain its stability through the generations have been built over the years. The foundation on which it is based, and adjusts each cultural system is the set of values shared by the largest group of individuals.

The origins of the values of a population are found in geographic, demographic, political, genetic, historical, technological and economic. They initially favor the development of a society, then they guarantee the stability of the institutions that regulate and ultimately promote the development of a particular family structure, political, legislative. As in a virtuous circle, are also the same institutions that have become mandatory, strengthen the rules and values and bring into balance in case of shock system. The values of a given population are strengthened over time thanks to a self-regulated balance. The cultural systems that are able to adjust this balance, despite the shock, have perpetuated over time, while those that were not able to regulate itself in the face of excessive disturbances have dissolved [Amato, 1995 Cotesta, 1999 Di Maria, 2006]. The differences between countries can therefore be traced to a variety of factors that are decisive as the common culture. Culture refers to that part of conditioning that individuals share with other members belonging to the same nation, region or social group.

It is an interactive set of common characteristics that influence the response of a certain group of people to external stresses and is the determining factor of difference between countries. [Ambrosini, 2005 Williams, 2004]. In particular, the Mediterranean Sea, and its geographic location, for historical and political reasons is a symbolic meeting place between very different cultures. Among the countries that overlook the shores of this sea special attention can be given to cultural differences between Italy and the countries of North Africa (Egypt, Libya and the Maghreb countries like Morocco, Algeria and Tunisia). Italy, located on the edge of the Mediterranean, has the typical cultural features of the European system in which strong national traditions are combined with a degree of openness to diversity, ideological pluralism, and a variety of behaviors. The countries of North Africa, on the other hand, are characterized by a strong ethnocentrism which can lead individuals to take confrontational behavior towards bearers of a different culture subjects. These countries are characterized by homogeneity in them and a low propensity to acceptance of different cultural models.

Therefore, they are not very prone to a process of integration in order to defend the values tied to their historical tradition. In these areas of cultural interaction processes may be ineffective and ethnic minorities are often forced to submit to the dominant groups. In these contexts, the lack of effective interaction between beliefs and values has often led to intercultural conflicts, which if unresolved, have had dramatic consequences for the entire population [Vannini, 1998]. The economic-geography studies bring back the cultural specificities of the countries of North Africa in historical and religious factors. From a historical point of view, the North African area was conquered by the Romans is that the Arabs of the Middle East. The various dominations have left a decisive mark throughout the area, spreading on the one hand the Latin culture and the other Islamic culture. Islamic culture, in fact, is not affected by the European colonization of France (Tunisia, Algeria and Morocco), United Kingdom (Egypt) and Italy (Libya). The various dominations have, however, given cultural and ethnic homogeneity is characterized by the dominance of the Muslim religion and a level of economic development than the rest of the African continent.

On the African continent live Islam, Christianity and various traditional religions that resist the spread of major religions. The presence of Christianity dates back to the early centuries of Christianity, and involved the northern coast of Egypt and the Ethiopian plateau, spreading not only in coastal areas also in the inland areas [Coccia, 2004 Livi Bacci, 2002]. Islam has spread with the arrival of Muslims from the Arabian Peninsula in North Africa [Barni and Villarini, 2001 Galieni, 2000]. The Islamic religion, influences beliefs and the values of religious, social and economic integration of the Arab countries. In particular, in the Koran only a small part is about the religious precepts to be observed, while the remainder is dedicated to the social and economic conduct [Collinson, 1994 Faccioli, 2004].

The lack of a hierarchical order in the Sharia has meant that you were creating various Koranic schools. According to the Sharia the property belongs only to God and man is the possessor pro-tempore. If the owner makes a bad use, the community of the faithful can expropriate [Baumann, 2003 Boccagni, 2003]. Always according to the moral law, the income of an individual is to be divided into consumption, savings (zakat) and investment. In the Islamic religion, is the interest that usury is forbidden and even Islamic banks seek alternative forms of return on capital. The equality in compliance with religious norms is an aspect of Islamic culture that creates significant problems for businesses from other cultural contexts [Collinson, 1994 Faccioli, 2004].

The clear distinction between what Islamic culture allows and what does not, the close connection between the spiritual and social life, and the affirmation of the principles of self-identity and self-categorization, used to classify the countries of North Africa, with particular reference to the extremist, as little inclined to welcome monolithic contexts and interactions with investors with different cultures [Cavazzuti, 2003 Di Sciullo et al., 2005]. Added to this is that none of the countries can be considered free and democratic, despite the gradual progress of Morocco and Egypt. Moreover, often the main human rights are not respected and the living and economic conditions are burdened by a voluntary closure to the dialogue. Political turmoil and instability of rights make it very fragile the whole area, pushing the population to use

Table 1 Starting a business

Name	Rank	DTF	Number of activities	Time to start	Costs %
Europe	–	90.21	5.0	12.1	5.3
Italy	46	91.22	5.0	5.0	14.1
North Africa	–	78.71	8.0	18.9	28.1
Egypt	73	88.14	7.0	8.0	9.2
Libia	144	73.50	10.0	35.0	19.9
Magreb Algeria	141	74.07	13.0	22.0	11.0
Morocco	54	90.33	5.0	11.0	9.2
Tunisia	100	83.60	10.0	11.0	4.2

Source: World Bank 2015

the banks of the coasts for the journeys of hope towards Europe.

NORTH AFRICA

The North Africa represents an important node connecting Europe and the Middle East. On the one everyone, old morphologically, the region as a whole has a coastal area, a desert and an inner area [Frisanco, 2002 Salvatori, 2005]. The Mediterranean area is flat and enjoys a mild climate. In this area there is the highest concentration of human settlements, major cities and the most important economic activities. Almost all the major cities of Tunis, Algiers, Oran, Tangier, Rabat and Casablanca ports are situated there too. The mild climate favors the areas of the Maghreb (Morocco, Algeria and Tunisia), where the Atlas relief blocks the winds from the desert. The area occupied by the Sahara desert is famous for its sandy areas, rocky and stony. The difficult climatic conditions make it little populous. The inner part is, however, a densely populated area, with very high values even in rural areas. In particular, Morocco is the most mountainous country, Tunisia has large desert areas, while Algeria has the largest desert area [Giro, 2002 Lazzarini, 1994].

From a socio-economic point of view, the data provided by the World Bank, which annually prepares Doing Business, can help you identify the number of procedures, time and costs that a private limited company of small and medium size takes to start activities in a North African country. In particular, from the 2015 data it shows that the North-African countries where the ease to start a business is more similar to Italy (46) are Morocco (54) and Egypt (73), followed by Tunisia (100), Algeria (141) and Libya (144) (Table 1) [World Bank, 2015].

Despite the differences between the Maghreb countries, it highlights the common political, economic and social factors that have led to a flow of migrants to Europe. Economically, in fact, the whole of North Africa is, on the whole, backward and poor [Landuzzi et al., 1995 Scanu, 2001]. Agriculture still accounts for a significant part of the workforce. Algeria has a production system dominated by the extraction of hydrocarbons, especially natural gas, exported in large quantities to Italy. Morocco is a tourist destination of great interest and can rely on the exploitation of phosphate deposits and iron ore. Tunisia is the country with the most balanced economy that articulated in agriculture, fisheries, industry and tourism. In the semi-desert areas, finally, it is still practiced nomadic livestock, especially sheep and goats.

EUROPE

The cultural differences between Europe and Africa are important elements not only for business interaction between companies that decide to internationalize, but also for the integration of the flow of individuals who decide to leave the southern shores of the

Mediterranean to the North shore. This flow is composed of people who move to a country other than that of habitual residence to live in the target country [Lizza, 1991 Simoni and Zucca, 2007].

The migration of individuals is an inevitable phenomenon in a time characterized by economic and political crisis and marked by social inequality. However, in recent years this flow has steadily increased due to wars, political instability, economic crisis, social and religious fundamentalism clashes countries of origin. In particular, the civil war in Syria has led to the largest movement of people since World War II to today. Refugees from South Asia, Afghanistan, Eritrea fleeing wars, oppression, social unrest, poverty, torture, arbitrary detention and various forms of repression of human rights [Mantovan, 2007 Sarpellon, 2004].

In 2015 the balance of foreigners in the European Union has been positive and has assumed alarming proportions. The European Union and North America today are the main poles in the world for reception of foreigners. In Europe, the foreign human flow is directed mainly to Italy, France, Spain, Germany, Sweden and Switzerland.

The geographical proximity to countries hit by the economic crisis, wars and socio-political instability has made Italy the entrance gate to the European Union for millions of foreigners. The High Commission of the United Nations Refugee Agency [UNHCR, 2015], most of the direct migrants in Europe that sail from Libya, Egypt and Morocco and land in Italy come mainly from Syria, Eritrea, Gambia, Senegal and Somalia. These migrants follow paths that cross the Sahara, West Africa and the Horn of Africa. This human flow that has distant origins (in 1996, for example, about 283 people died in a trip from Alexandria to Italy) has broadened considerably in recent years due to wars and socio-economic crisis in the countries of origin becoming a million dollar business [Ravlin, 1995 Messina, 2001 Melis, 1999 Scanu, 2000 Sciortino, 2003 Lizza, 1991 Maltoni, 2003 Losi, 2000].

The 2013 report of the United Nations High Commissioner for Refugees [UNHCR, 2015] shows that the cost of travel from North Africa ranges from $ 200 to $ 1,000 while from the rest of Africa it is between $ 1,000 and $ 6,000.

The smugglers are, in fact, able to combine crime and tribal loyalty and able to adapt to changing circumstances as they carry on their activities. In particular, the transport of migrants from Libya to Europe is a business circa170 million. The journey from Libya to Italy is a hundred kilometers. Once left the Libyan coast, a distress call was made in the hope that migrants are picked up by a merchant ship passing through or by the Italian Coast Guard. In many cases, therefore, the ship goes without crew or the crew abandons it during navigation. The majority of those who make long journeys from Africa arrive in Italy through the small island of Lampedusa [Morlicchio, 2000 Recchia and Allam, 2002].

UNHCR [2015] estimated that about 80,000 immigrants have the Mediterranean to reach the Italian coast in 2013, about 219,000 in 2014 and about 50,000 in 2015. However, as the EU regulations attribute the responsibility to the first EU country where a migrant comes, Italy has had to handle a large flow of migrants for the position it occupies in the Mediterranean. Despite wondered aid to Europe, reaching an agreement on an equitable burden-sharing of this mass exodus it has not yet been reached.

ITALY

According to Istat processing reported in the Caritas-Migrantes reports [2013, 2014, 2015], the main reasons that drive people to leave their countries on the southern shore of the Mediterranean to Europe through Italy are political and socio-economic (work, family, study, political asylum, etc.).

The main reason of the increasing flow of individuals from the South shore of the Mediterranean enter Europe through Italy is represented by wars and political instability in countries of origin. To political persecution were added to war refugees flows due to international instability and military conflicts. In 2014 42.5 million people were forced to flee to other countries, of which 26.4 million internally displaced people and 15.2 million refugees who have fled the country of origin to avoid racial persecution, religious, political [Natale e Strozza, 1997 Picciolini, 199].

In the same year they were submitted 895,000 applications for asylum. Of them, 277 thousand were presented in the EU, with 81,952 cases in Italy. Many are the hotbeds of war, some known and other forgotten, and 1.2 billion people live in despotic regimes (34) or in fragile states (43) struggling with degradation, poverty and emergencies. In Italy, from 1950 to 1989 they were 188 thousand asylum applications and from 1990 until 2014 have been joined by around 326 thousand for a total, since the war, more than half a million. The annual average was about 8 thousand questions, exceeded by almost four times in 2014.

The economic and employment conditions are historical drivers of the foreign flow coming in Italy (Table 2). The movement of workers is influenced by socio-cultural factors such as the existence of communication networks between the countries of origin and host country. Foreigners who in 2014 moved to Italy for business reasons were 817,596. Of these, the majority was directed in the regions of North West (286 815), center (208 879), North-east (187,341), South (103 277) and Islands (31,284) [Caritas-Migrantes 2013, 2014, 2015].

In the periods of intense crisis, they found precarious accommodation and characterized by psychological contacts with the employer not formalized legally. In addition to the regular admission difficulties, considerable difficulties in recognition of qualifications and previous professional skills have reduced the chances of finding work further.

Contract workers are distinguished from previous because they are generally subjected to specific rules, the entrance to which is authorized for limited periods in order to absorb temporary manpower needs and defined. The initiative is in response to the discrimination faced in later developments to the employees. However, it could also bring in psychological motivations, religious and cultural background of the fact that some ethnic groups are more likely to businesses and self-employment on the basis of historical example represented by the Jewish Diaspora. The reports establish that foreigners may have implications in determining the economic success of minorities [Navarra, 2000 Pasquino, 2002]. The informality of the relationship, the family ties and religious affiliation, a promotion and sanction system connected to a particular interplay between implicit and reputation requirement that makes mutually dependent individuals involved in trade, lower the level of opportunism between the parties involved by encouraging the development of the activities carried out by them.

Through a network of foreign relations can create a cluster of highly interdependent firms as they are characterized by an almost

Table 2. Migrants in Italy

Provincie	Job	Family	Study	Asylum	Other	Total
North-west	286.815	259.290	20.228	17.924	9.858	594.115
North-east	187.341	188.790	10.628	13.249	5.893	405.901
Center	208.879	157.185	17.599	19.715	25.310	428.688
South	103.277	61.835	2.760	19.337	6.981	194.190
Islands	31.284	24.896	844	11.727	3.474	72.225
ITALY	**817.596**	**691.996**	**52.059**	**81.952**	**51.516**	**1.695.119**

[Caritas-Migrantes, 2014]

exclusive use of ethnic workforce, and the possibility of receiving mutual moral and economic support in social integration as well as economic [Old, 2012 Vienot, 2003]. Foreign groups are concentrated in a particular geographical area and organize a variety of businesses, intended to serve first the internal market of the group, and following a process of integrating a larger population. The migration of families was determined by social factors, although the original migration that started the chain has been of an economic nature [Vitale, 1998 Zamagni, 2001]. In 2014 were about 691,996 foreigners arrived in Italy for family reasons. The increase in migration from the south to the north of the Mediterranean for this reason it was also influenced by the spread of Western cultural models, for reasons of study or phenomena such adoptions.

NORTH-AFRICAN COMMUNITY IN ITALY

The first human flows from North Africa to Italy date back to the 40s and see how young players wishing to improve their standard of living. The political and social crisis has led many Africans to move to Italy to escape from the country of origin. The host location and placement within Italy of the foreign flow from Egypt appears to be the product of cultural interaction between very different worlds. Italy itself as a multicultural country that is open to diversity, in which different cultures interact and emphasis is placed on the pluralism of ideas and behavior. North Africa that is configured, however, as a multicultural area, closed to diversity, characterized by strong internal homogeneity and a low propensity of different cultural models. In such contexts, the lack of effective interaction between beliefs and values has often led to intercultural conflicts, unresolved, have had dramatic consequences. In these areas, also the cultural interaction attempts may not be very effective if ethnic minorities are in a position of inferiority and are forced to undergo the power of the dominant groups. In particular, the North-African communities in Italy tend to form subcultures which reproduce the departure society. They very often are linked to a set of relationships, symbolic and materials that continue to determine their identity while being absent and unknown to the host society, in which they are required to integrate [Cavazzuti, 2003 Di Sciullo et al., 2005].

According to the report on the presence of immigrants of the Ministry of Labour and Social Policy [2015], Interior Ministry and Istat archives at the beginning of 2015 the Egyptians holders of a residence permit are the eighth largest number of non-EU community. A key feature of this community is its composition, predominantly male and young, with a strong child component that also includes many unaccompanied children. Among them, in fact, women account for 30 % while the remaining 70 % is divided among minors (32 %) and young people aged 25–39 (37 %), at the expense of the age group 18–24 (7 %) and adults (24 %). The national higher concentration of the Egyptian community is the North (82 %), followed by Centre (16.9 %), South (1.1 %) and Islands (0.5 %). The region with the most residents Egyptians is Lombardy (68.2 %), followed by Lazio (13.9 %), Piedmont (5.7 %), Emilia Romagna (4.2 %) and Tuscany (2.5 %). Among the settlement provinces, the first of all is that of Milan, where he lived half of Egyptians in Italy (46.9), followed by Roma (13.5 %), Brescia (6.2 %), Turin (4, 6 %) and Pavia (3.6 %). The long migratory history of the Egyptians in Italy is also reflected in the large number of permit holders EC for long-staying, a title not an expiry date that is released after at least 5 years of legal and continuous residence (58.2 %).

According to the report on the presence of the Ministry of Labour Immigrants and Welfare [2015], the Moroccan communities from the 40s were the star of intense migrations in the Mediterranean region to direct through Italy to France. The first wave of Moroccans in Italy consisted of unmarried males only willing to do menial jobs as agricultural laborers or street vendors. Following arrived families, they attracted students from universities or fleeing the socio-economic problems of the country of origin. The southern regions, the first landing areas, were abandoned to the North which was more promising in terms of employment. The Moroccans have always been the first largest foreign communities in Italy. Moroccan immigrants in Italy the holders of a residence permit are, according to the Interior Ministry archives reviewed by Istat, 13.5 % of all non-Community in the country. Of these, 44.1 % are women. Furthermore, particularly high is the percentage of minors (30.3 %). The major confluence area is definitely the North, where the Moroccans are focused for nearly 72.5 %. The region with the most Moroccans residing is Lombardy (24.1 %) followed by Emilia Romagna distance (15.5 %), Piedmont (13.7 %), Veneto (12.9 %) and Tuscany (6,2 %). Among the major settlement provinces, the first is Turin, followed by Milan, Bergamo, Brescia, Verona and Modena. The migratory history of Moroccans in Italy also results in a high number of people with permits for long-residents (60.4 % of Moroccans). According to Istat in Italy of Moroccan nationality population of working age, 44 % is actually occupied, 39.4 % are inactive. It is therefore disturbing the unemployment rate of Moroccans (27.2 %). Among the main employment sectors are services (52 %) and industry (43 %).

According to the report on the presence of immigrants of the Ministry of Labour and Social Policy [2015], the beginning of the Tunisian migration in Italy dates back to the mid-60s when the first Tunisian fishermen began to arrive, attracted by the demand for labor in fishing fleet of Mazara del Vallo. But it was especially during the '70s and' 80s, thanks to word of mouth, the reduced cost of the trip, the geographical proximity and the absence of restrictions on entry, that the presence starts to become substantial. Until the '90s, the closing immigration policies pursued by France, Germany and the Netherlands, the economic crisis in Tunisia and the expulsion of Tunisians from Libya carrying more and more these migrants to head for Italy. In Italy the immigrants Tunisian citizenship holders of a residence permit are, according to the Interior Ministry archives 3.2 % of all foreigners residing in the country. Among these women have little effect while the minors affect much.

The area of the greatest concentration of Tunisian society is the North Italy (62.2 %), followed by Central Italy (18.0 %), Islands (13.6 %) and South (6.2 %). The region with the largest number of Tunisians residing is Emilia Romagna (22.9 %) followed by Lombardy (20.7 %), Sicily (13.1 %). The long history of migration of Tunisians in Italy is also reflected in the high share of the EC allowed holders of long stay (68.4 %). Of Tunisian nationality population of working age, people actually in employment are slightly less than half (46.0 %), while it is 37.8 %, the share regarding inactive. Among the sectors, the industry accounts for almost half of Tunisian workers (49.3 %), followed by agriculture (19.3 %).

CONCLUSIONS

The concrete integration of the North-African community in Italy requires the emergence of a new paradigm of interpersonal behaviors that follow codes and believe that ensure reciprocity of benefits. These are the principles of solidarity that must permeate relationships in unbalanced situations, if all of the partners want to aim to achieve the synergistic effects of a cumulative and lasting growth. This is a slow, incremental process rather than revolutionary, since the culture of a country is much more difficult to change as much as it is consolidated and shared, and the changes can occur only very slowly since the culture, when it is shared, it is not present only in the mind of the individual, but it is also crystallized in institutions. For the development of cooperation that respects diversity, it is necessary that individuals of both cultures acquire a way of thinking of both systemic, where the whole prevails over its parts, both strategic, face immediate acceptance of sacrifices against benefits deferred and conditioned.

To avoid the danger of ethnic conflict must facilitate a process of integration of different groups both among themselves and with the native population. Integration is, in fact, a process of insertion of foreigners in modernized and democratic contexts that contributes to building a multi-cultural society, where the main elements are derived from the interests or values of indigenous peoples, overcome only thanks to the generational change. It is a slow process that in some cases comes to fruition only in the second or third generations. This phenomenon in its two-way nature dictates that by a foreign side to respect rules and values of a country in preparing for deep acceptance of them, and on the other that predisposes National State of actions in support of the effective acceptance of foreigners from the population local, founded on mutual respect and shared goals. ■

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Received 09.03.2016 **Accepted 08.11.2016**

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DOI: 10.15356/2071-9388_04v09_2016_02

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DOES ECONOMIC-GEOGRAPHICAL POSITION AFFECT INNOVATION PROCESSES IN RUSSIAN REGIONS?

ABSTRACT. A favourable economic-geographical position (EGP) of regions and cities is one of the factors of their socio-economic development. Economic agents can take advantages of their proximity to the major markets of goods and services, thereby reducing their transport costs and increasing their profitability. In the sphere of innovation, proximity to the innovation centres may also significantly affect the creation of new knowledge and technologies, due to the existence of tacit knowledge and knowledge spillovers. The authors propose the term 'innovation-geographical position' by analogy with EGP. It has been demonstrated that location matters to regional innovation output. If there is 1 % more new technologies in neighbouring regions, there are approximately 0.35–0.58 % more newly created technologies in the target region. Proximity to the world centres of new technologies has even greater impact.

KEY WORDS: innovation-geographical position, knowledge spillovers, Russian regions, innovation, R&D, market access.

INTRODUCTION

"Economic-geographical position" (EGP) is one of the key categories in the area of regional studies in Russia. It is one of the few concepts originally emerged and developed in the national science; it has been rarely used outside of the Russian-speaking academic community[1].

Modern studies of the factors of regional development and inequality in Russia [Lugovoy et al., 2007; Grigoriev et al., 2008] point to the link between the geographical location of regions and their socio-economic characteristics[2]. At this, mainly in literature, there exists a qualitative assessment of a "favourable" or "unfavourable" regional EGP.

Several authors [Cairncross, 2001; Smirnyagin, 2012] believe that given the acceleration of the development of communication technologies, the cost of interaction between economic agents is rapidly falling; therefore, the category "position" itself is no longer so important. The category "place", is much more significant because it preserves a strong differentiation in the living conditions of the population, according to their capacity to create and implement new technologies. Remote and underdeveloped areas are still less attractive to migrants, investors and innovators.

The previous authors' works [Zemtsov, Baburin, 2016; Baburin et al., 2016.; Zemtsov,

[1] In the English literature, a widely accepted term is "market access" [Krugman, 1991].
[2] Geographical location also includes natural characteristics of a region, thus, often EGP is associated with agro-climatic resources, coastal location, and availability of natural resources, which is inconsistent with the original understanding of considered category.

Baburin, 2016] have demonstrated that there are high correlation coefficients between economic-geographical position of Russian regions and cities and their economic output growth, increase in investment, volumes of foreign trade, migration growth, and diffusion of new technologies.

Thereby, advantageous EGP of regions and cities can be considered one of the factors of their socio-economic development. But does it matter for regional innovation output whether it is nearby other innovative regions or centres of new technologies?

The aim of this work is the application of methodology for assessment of regions' EGP potential to calculate the possible benefits from their proximity to the major centres of production and diffusion of new knowledge and technologies.

APPROACHES TO ASSESSMENT OF THE ECONOMIC-GEOGRAPHICAL POSITION POTENTIAL

Economic-geographical position of the region is a historically established, but a changing set of potential spatial relationships between economic agents of the region and external factors influencing the regional development [Zemtsov, Baburin, 2016a]. Primarily, the spatial relationships between objects are determined by the distances between them. The object is able to change its position striving to achieve the most favourable location in space, i.e., to reach the point at which the potential impact of external conditions would be most beneficial for its development. For example, Orenburg changed its location three times. However, the ability of large territorial systems (e.g. regions) to move is limited. In this case, change in the EGP potential of specific areas within the region affects the economic agents that, through moving, transform the internal structure of the region. That is, the regions are optimizing their territorial structure.

Problems of EGP were discussed by a number of economic geographers. N.N. Baranskiy, gave the classical definition of EGP [Baranskiy, 1980, p. 129]. A significant contribution to the development of the concept was made by I.M. Maergoiz [Maergoiz, 1986], Yu.G. Saushkin [Saushkin, 1973], E.E. Leizerovich [Leizerovich, 2006], A.I. Treyvish [Treyvish, 2009], L.I. Bezrukov [Bezrukov, 2008], and other scientists.

The geographical location as a qualitative characteristic of an object can be central, peripheral, or neighbouring. To assess centrality of the object in the transport network, the topological distance method is often used. Neighbouring position of the two territorial systems, other things being equal, usually is a favourable factor for their development. The proximity of a large neighbour can bring the benefits of cooperation, relocation of businesses, diffusion of new technologies, etc.

The work by [Zemtsov, Baburin, 2016] gives a detailed overview of the theoretical and methodological approaches to the assessment of economic- geographical position in Russia and abroad. There are two main methodological approaches: metric (distance from a major centre, market, etc.) and topological (neighbouring position, location in a settlement system, etc.).

Assessment of transport-geographical position (TGP) includes estimates ofthe benefits associated with a city's distance to the main transport arteries, its position in the transport system, and the costs to deliver goods and people [Bugromenko, 1981; Tarkhov, 2010]. One of the most developed methods of TGP assessment is to measure the economic distance, i.e., the distance of cities in terms of transport costs [Rakita, 1983; Blanutsa, 2010].

Many authors use gravity models for assessment of favourable position of regions and cities. A prerequisite for the use of this type of model is the law borrowed from physics on the dependence of the interaction of two objects on their size and degree of closeness [Lukermann, Porter, 1960; Harris, 1954]. A region can potentially interact with other regions; ceteris paribus, interaction is higher if two regions are closer and bigger.

The classical model of interaction between the two regions was developed by C. Harris [Harris, 1954]:

$$V_{ij} = \frac{MV_j}{R_{ij}}, \quad (1)$$

where V_{ij} – the trade flow between regions j; MV_j – the market potential, such as gross regional product (GRP) in the *j-th* region; and R_{ij} – the distance between the regions.

The areas of applications of gravity models include assessment of the market [Hanson, 2005; Head, Mayer, 2010], demographic [Stewart, 1947; Isard, 1960], and innovation potential [Baburin, Zemtsov, 2013] and assessment of trade [McCallum, 1995; Kaukin, Idrisov, 2013] and migration flows [Andrienko, Guriev, 2003]. However, it is widely thought that the existing approaches to the construction of a formal model or an empirical evaluation of the EGP potential of the Russian regions have not been yet well developed.

WHY IS GEOGRAPHICAL POSITION IMPORTANT FOR INNOVATION?

The important features of knowledge as a public good are indivisibility, ability to use knowledge an unlimited number of times and in various fields of activity (non-rivalrous), and inability to prevent other agents from its use [Nelson, 1959]. Therefore, innovation activity of one agent generates positive externalities for other agents – knowledge spillovers [Audretsch, Feldman, 2004; Jaffe et al., 1992]. The agents are not necessarily interacting directly; they can use, for example, open data.

Knowledge spillover is a process, when the knowledge created by a company may be used by another company without compensation or with the compensation lower in value than this very knowledge" [Synergy of space..., 2012]. The higher the volume of knowledge flows, the more new technologies are created in the region, ceteris paribus. In this case, we are talking not only about the territorial aspect of knowledge spillovers but also about the inter-sectoral. The innovation activity of the enterprise in a specific sector is positively influenced by external effects of knowledge coming from other sectors. The role of knowledge flow in high-tech clusters has been demonstrated by successful examples in the United States (Silicon Valley, Seattle), in Canada (Montreal), and in other countries.

The intensity of knowledge spillovers depends on the proximity of parties; other types of proximity are also important in addition to spatial[3] [Boschma, 2005]:

- Cognitive – degree of proximity of the parties' knowledge.
- Organizational – degree of governmental bodies unity.
- Social – degree of trust between the parties.
- Institutional – degree of institutional unity.
- Process – degree of compatibility of technologies.

Geographical proximity alone does not necessary lead to knowledge spillovers; cognitive proximity is necessary. Rather, the spatial proximity plays a role of an indicator of other types of proximity.

Innovations, being the result of human activities, include formalized knowledge that can be transmitted in the form of papers using formulas, graphs, etc., and non-formalizable knowledge possessed by only the innovator. The latter is called tacit knowledge [Polanyi, 1967]. This fact is crucial for regional studies,

[3] The concept of proximity of firms has an apparent analogy with the economic-geographical position of large territorial units (cities, regions, and countries).

since tacit knowledge is concentrated in locations of scientific schools and major research centres, and the transfer of such knowledge is possible in a geographically limited area.

With the acceleration of the development of information and communication technologies (ICT), capabilities of remote interaction, distance education, remote co-writing of papers, etc., are rapidly evolving. There is a feeling that sooner or later distance will cease to be a significant factor for knowledge creation. However, the conditions of human living environment continue to vary considerably and they differ strongly for the creation of new technologies which are concentrated in large cities, metropolitan areas, and science towns.

The process is known as "glocalization", when the routine functions of the city spread around the world, while the unique (the most high-tech) functions are concentrated. The paper by [Glaeser, Ponzetto, 2007] examines a theoretical model in which industrial cities (such as Chicago) in the new conditions of reduced transport costs lose in comparison with those which initially focused on the new economy (e.g., New York or San Francisco). Industrial production can be placed almost everywhere, but the knowledge is still concentrated. And the cities are increasingly competing for innovators, including creative class [Florida, 2005].

In addition, knowledge is cumulative; it takes time for its *embeddedness* in social systems, and consequently, even emigration of innovators may not always lead to the desired increase in new knowledge creation without proper institutions. "Embeddedness of innovation" refers to the formation of networks of interaction of innovative agents, forming the cultural environment that is open to new ideas, community interest in innovations, and innovators' high prestige [Oerlemans et al., 2001]. Then ***embeddedness*** is the intensity of the involvement of regional communities in the innovation process.

By analogy with the economic-geographical position of regions, we should be talking about the differences in the innovation-geographical position (IGP) of various regions, where some of them are closer to the centres of generation of new knowledge (or contain these centres within), which accelerates the process of technology transfer and diffusion of innovations. And it is not only geographical, but the institutional, cultural, and other proximities. Such regions may have more favourable factors for the import and export of technology, attraction of foreign innovators, etc.

This IGP, as well as the EGP, is a category that has the potential (probabilistic) character; that is, its benefits may be realized or not.

Bottazzi L. and G. Peri [Bottazzi, Peri, 2003] conducted a study based on data on patent activity and the costs of innovation in the regions of Eastern Europe in 1984–1995 to define the maximum distance after which the effect on expenditures for R & D in neighbouring regions ceases to be meaningful:

$$\begin{aligned} \ln(Patent_i) = \beta + \varepsilon_0 \ln(RnD_i) + \\ + \varepsilon_1[m_{0-300} \ln(RnD)] + \\ + \varepsilon_2[m_{300-600} \ln(RnD)] + \\ + \varepsilon_3[n_{600-900} \ln(RnD)] + \\ + \varepsilon_4[m_{900-1300} \ln(RnD)] + \\ + \varepsilon_5[m_{1300-2000} \ln(RnD)] + \\ + D \times Country_i + u_i, \end{aligned} \quad (2)$$

where *Patent* – the number of national patents per employee in R&D; RnD_i – expenditures for R & D in the region *i*, mln euros; $m_{xy} ln(RnD)$ – average expenditures for R & D of the regions located at a distance over *x* or less than *y* km; and *Country* – country dummy variables that reflect the quality of institutions and infrastructure in individual countries. It is shown that research funding in the surrounding areas (at distances less than 300 km) has a positive effect on innovation activity in the target region.

The paper by [Von Proff, Dettmann, 2013] has shown that the distance between the inventors, who participated in the creation of patents in Germany, remained virtually unchanged over the past 15 years: 170 km – for public research and 190 km – for business.

The work by [Keller, 2002] showed that the distance of 1200 km from the nucleus of innovation leads to a significant reduction in the processes of diffusion of new technologies. That is, the proximity is important not only for the creation, but also for the dissemination of new knowledge and technologies.

The work by [Crescenzi, Jaax, 2015] on the patent activity in Russia used international patent applications as the dependent variable. The authors have also identified importance of knowledge spillovers from other regions, calculated using the distance-weighted expenditures for R & D of neighbouring regions.

The papers by [Zemtsov et al., 2016; Baburin, Zemtsov, 2016] calculated the patent potential of the Russian regions. It was impossible to measure the patent knowledge spillover using Russian data, since available information about patent citing is unavailable, but it was possible to estimate the amount of potential external effects associated with high density and proximity of patent centres. It is known that the number of mutual citations by inventors drops dramatically with increasing distance (more than 200 km) between the places of registration of patents [Audretsch, Feldman, 2004; Jaffe et al., 1992]. Therefore, we assumed that the greater the distance between the regional centres, where in most cases patent activity is concentrated[4], the lower the probability of interaction between researchers and, consequently, the lower the interregional knowledge spillovers. The patent potential of the regions [Baburin, Zemtsov, 2012] by analogy with the market potential (V_j) was calculated using the following specifications of the gravity model

$$V_j = \sum P_i / D_{ji}^n, \quad (3)$$

where P_i – the number of patents granted per 100 thousand residents in region (– regional centre) i; D_{ji} – distance from region j, whose potential we are trying to define, to region i, km; n – coefficient of proportionality, showing the rate of decline in the intensity of interaction between the inventors as the distance between them grows.

The patent potential is highly concentrated near Moscow metropolitan area and major regional centres: St. Petersburg, Nizhny Novgorod, and Kazan. The patent potential naturally decreases rapidly towards the eastern, less densely populated, and more remote from each other regions. It is an indicator of favourable innovation-geographical position. For example, the Kemerovo region does not have the high levels of patent activity, but due to its proximity to the Tomsk and Novosibirsk regions, it has an average patent potential. This may increase the intensity of interregional interactions between inventors and subsequently new knowledge creation.

The work by [Baburin, Zemtsov, 2016] identified the main factors of patent activity: human capital, expressed in terms of the proportion of employees with higher education, and expenditures for R & D. However, with the introduction of the patent potential into the model, it becomes the most significant variable. In the papers by [Zemtsov et al, 2016; Baburin, Zemtsov, 2016] it was demonstrated that the increase in patent activity in neighbouring regions by 1 % leads to an increase in the number of patent applications in the region by 0.5–0.56 %. This result indicates the presence of interregional innovation clusters, including Moscow, St. Petersburg, Volga, Siberia, and Ural, where patenting activity increases simultaneously; the mechanisms of this interaction require more thorough research.

[4] The patent activity may be high in a region due to the location there of a large science town; often, restricted-access territorial entities were created in the USSR within 50 km from the regional center.

The potential interregional knowledge spillovers can be measured either by the characteristics of the innovation potential in neighbouring regions (expenditures for R & D, number of researchers, etc.), or by mutual citation of patents and the number of joint papers and inventions. The number of joint patents, papers, and patent citations decreases rapidly with increasing distance. The analysed studies showed that above the distance of 120–150 miles, researchers hardly cite each other's patents and, therefore, do not interact either actually or virtually. For Russia, the distance may be lower due to lesser mobility and greater isolation of scientific schools.

METHODOLOGY OF ASSESSMENT OF THE INNOVATION-GEOGRAPHICAL POSITION OF REGIONS

The calculation of the IGP potential of the region *i* included the assessment of the interregional potential (IGP^{Reg}) and the international potential (IGP^{World}) according to the procedure described in [Zemtsov, Baburin, 2016]:

$$IGP_i^{All} = IGP_i^{Reg} + IGP_i^{World} = \sum_{j=1}^{n} \frac{MV_j}{R_{i,j}^{a'}}, \quad (4)$$

where MV_j – the number of international Patent Cooperation Treaty (PCT) applications in the region or country *j*; R_{ij} – the actual distance between the capital of the target region *i* and the capitals of other regions or countries, *j*, *n* – the total number of regions and countries, *a* – the empirical coefficient.

All parameters were calculated based on statistical data "Regions of Russia. Socio-economic indicators data". Data for PCT-patent applications were taken from the official website of the Organization for Economic Cooperation and Development (OECD).

The calculation of IGP^{Reg}, i.e., its position in relation to the Russian regional centres of new technologies, was conducted according to the formula (Figure 1):

$$IGP_i^{Reg} = \sum \frac{PatPCT_j}{R_{i,j}^2}, \quad (5)$$

where *i* is the target region; *PatPCT* is the number of PCT-patent applications; *j* is other regions of Russia (in all, 83 regions, without taking into account the Republic of Crimea and Sevastopol due to lack of data); and *R* – distance from the centre of region *i* to another Russian region *j* (km). We used the distance by rail; for regions where there are no railways, we used data on road and river routes.

Economic ties by land are less intense than by sea due to higher transport costs. Therefore, coefficient *a* in the denominator for sea interaction is lesser than for interregional relations. The general formula for calculating the capacity of the external IGP^{Reg} [5] (Figure 2):

$$IGP_i^{World} = \sum \left(\frac{PatPCT_q}{\min\left(R_{i,p}^2 + R_{p,q}^{1,5}\right)} \right) + \sum \left(\frac{PatPCT_n}{\left(R_{i,e}^2 + R_{e,n}^2\right)} \right), \quad (6)$$

where *q* – foreign countries, with which cooperation is mostly carried out through the Russian seaports; $R_{i,p}$ – distance from the target region *i* to the port region of Russia *p* (km), $R_{p,q}$ – distance from the port region of Russia *p* to a country *q* (km); *n* – countries with which the regions of Russia have the border and foreign economic activity is carried out mainly by land through regions *e*.

In the 2000s, the international IGP of the regions has changed substantially, i.e., their position in relation to large world centres of creation of new technologies (Figure 3). In 1998, the best situation was a characteristic

[5] IGP, measured by the proposed method, conditionally allows one to calculate the potential amount of joint research, joint patents, and patent citations in the case of the maximum development of scientific infrastructure.

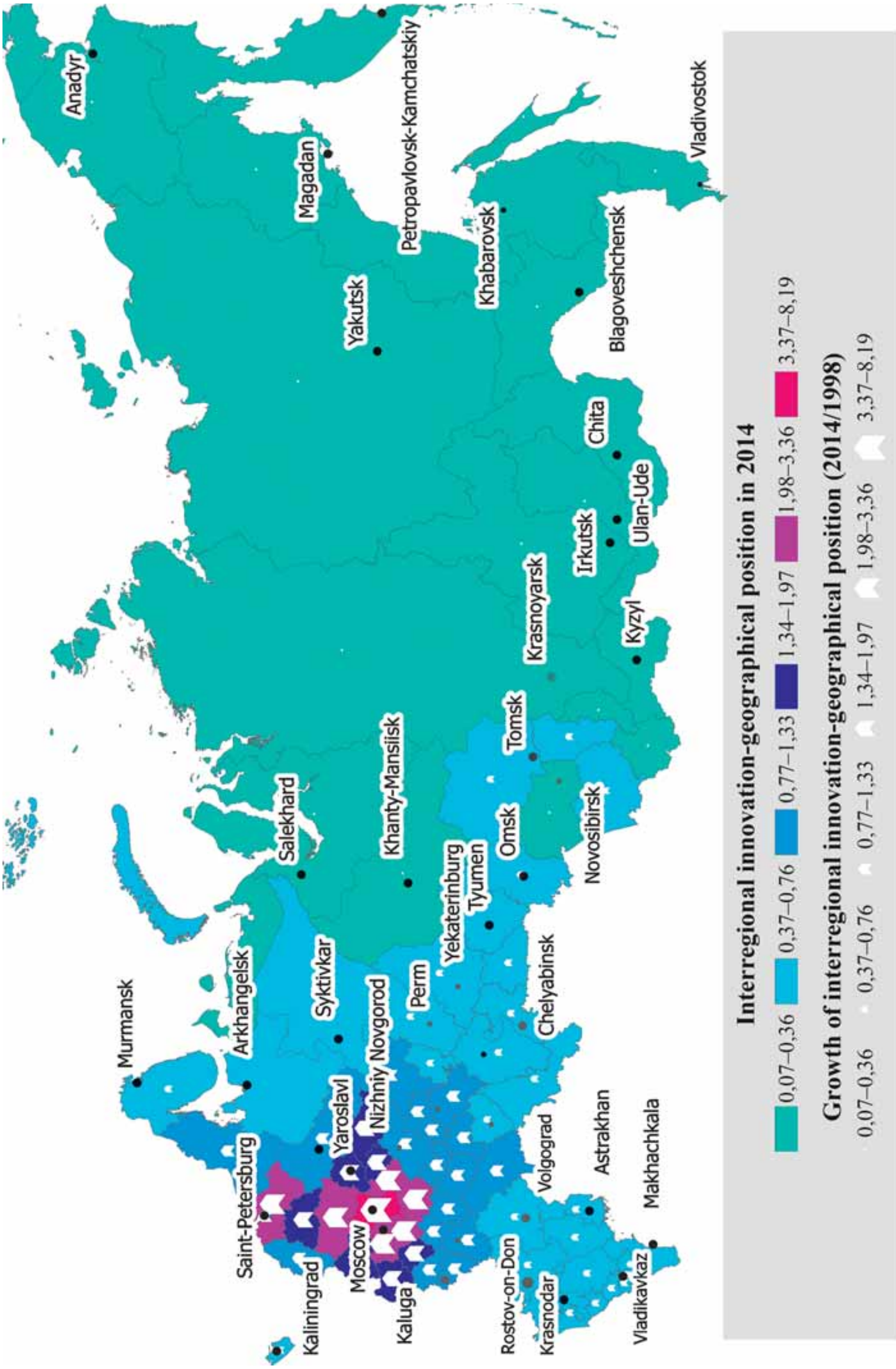

Fig. 1. Interregional innovation-geographical position of Russian regions and its dynamics

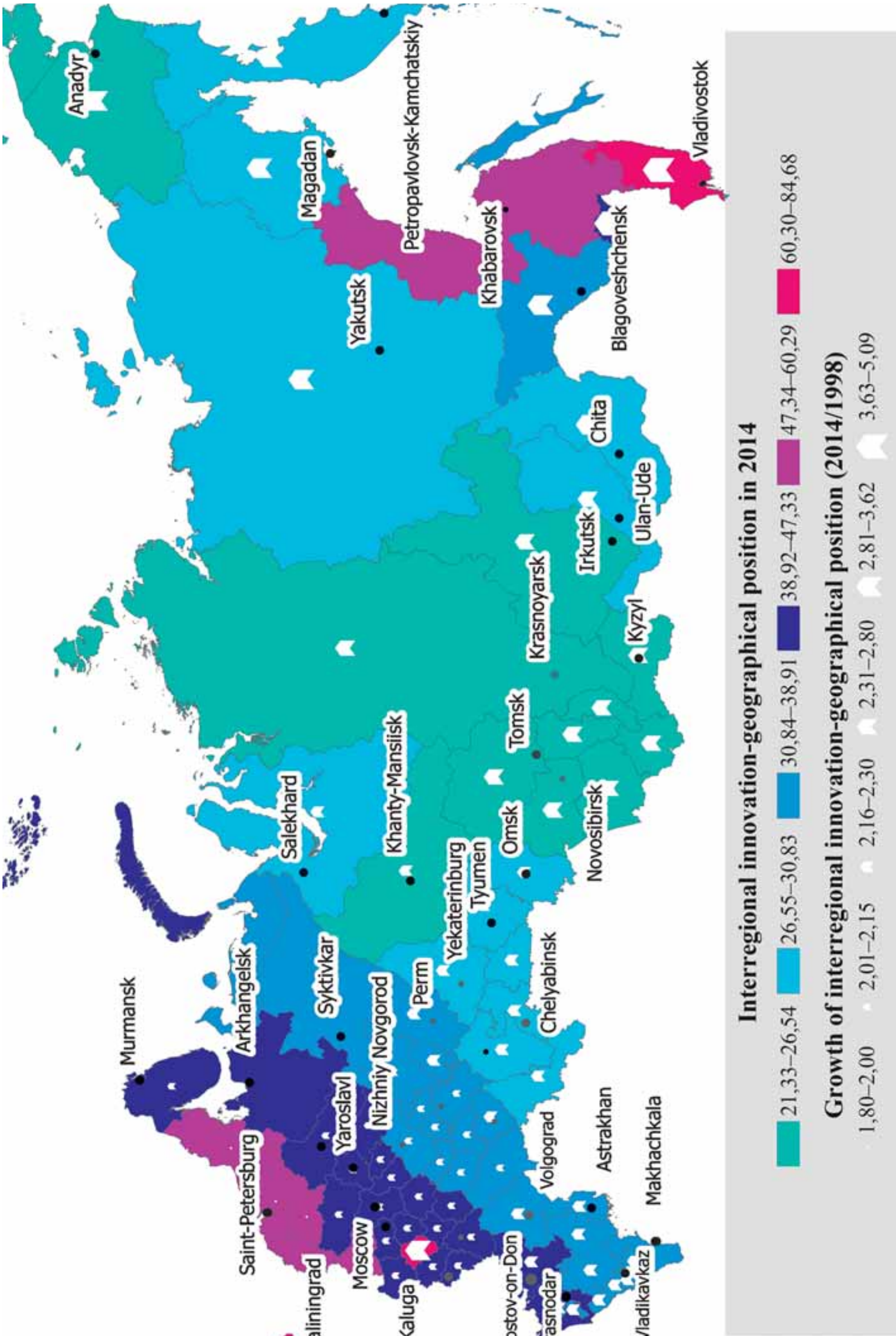

Fig. 2. International innovation-geographical position of Russian regions and its dynamics

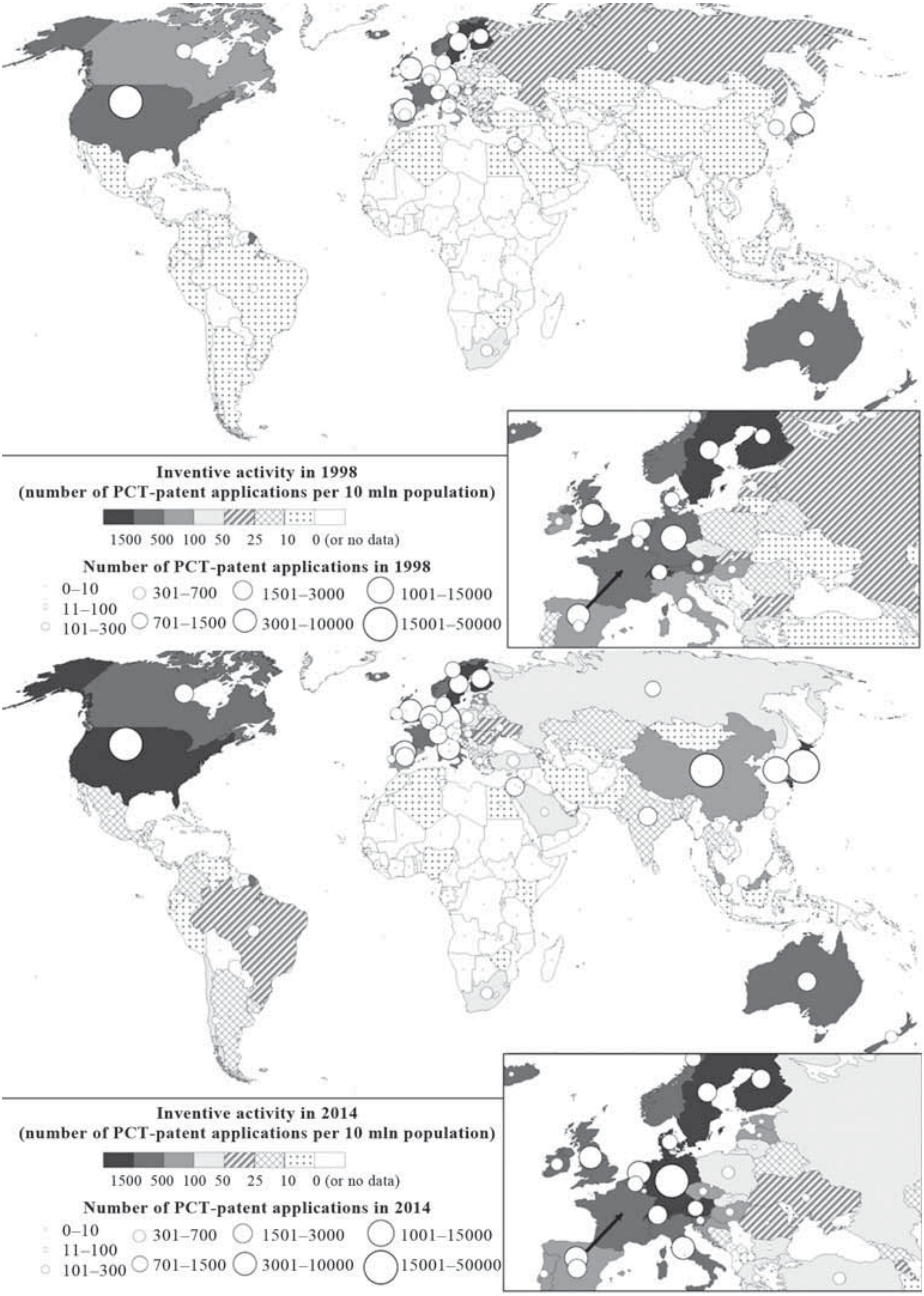

Fig. 3. International innovation-geographical position of Russia

Source: World Bank. URL: data.worldbank.org/

Table 1. The correlation coefficient between IGP, number of indicators of innovation sphere, and EGP in 1998–2012

Indicator	Interregional IGP potential	Total IGP potential
Total EGP potential	0.1164	**0.7247**
Interregional EGP potential	**0.8596**	0.2589
Interregional IGP potential	1	**0.4444**
Number of PCT-patent applications	**0.3074**	0.1445
Number of cellular phones per 100 persons	0.2275	**0.5986**
Share of organizations with internet access, %	0.1155	**0.3975**
Export of technologies, mln rubles	**0.2064**	0.1206
Import of technologies, mln rubles	0.2258	**0.2326**

of the western Russian regions, while in 2012, it became the feature of the Far-Eastern regions due to a substantial enhancement of innovation activity in China, South Korea, and Japan. Unfortunately, because of the cultural, institutional, geopolitical, and other barriers, these changes had almost no effect on the activity of the Russian Far East[6].

Appendix 1 contains information on various types of IGP and their dynamics for all regions of Russia.

THE MODEL FOR ASSESSING THE IMPACT OF INNOVATION-GEOGRAPHICAL POSITION ON REGIONAL INNOVATION OUTPUT

Table 1 shows how location, in relation to major regions that create new technologies, affects the number of new PCT-patent applications and export of technologies. Proximity to the major world centres of new technologies is associated with the total (aggregated interregional and international) potential of EGP and the diffusion of new technologies (mobile, internet, technology imports).

[6] Quite a large volume of work done in preparation for the summit of the Asia-Pacific Economic Cooperation (APEC), including the construction of a new campus of the Far Eastern Federal University. In the future, these actions should encourage technology transfer from APEC.

Our goal was to understand if regions' IGP affects their ability to create new technologies and to what extent.

The panel regression with fixed effects was chosen as the basic model based on the fact that the sample is not random. The model has the form:

$$\ln(Innov_{i,t}) = \alpha + \beta_1 \times \ln(Rnd\_any_{i,t}) + \\ + \beta_2 \ln(Hum\_Cap_{i,t}) + \beta_3 \ln(KSpill_{i,t}) + , \\ + \beta_4 \times \ln(X_{i,t}) + \varepsilon_{i,t}, \qquad (7)$$

where i – a Russian region in time-period t, *Innov* – indicators of innovation output, *RnD_any* – R & D expenditures, *Hum_Cap* – indicators of human capital, *KSpill* – indicators of potential knowledge spillovers, X – indicators of other factors.

The Russian regions in general are characterized by low share of commercialized national patents, which in the 2000s did not exceed 7 %. Data on PCT-patent application may be a more reliable measure for assessment of the level and character of inventive activity. However, its shortcoming is a low patent activity for most of the regions.

Because of disadvantages of the data, we have introduced a new parameter, which reflects the number of potentially commericializable patents (*Innov*):

$$Innov = 0.08\text{Pat\_rus} + 0.5\text{Pat\_PCT}, \qquad (8)$$

Table 2. The results of the innovation output modelling (Innov)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Parameter	0.88 (0.18)***	–0.12 (0.15)	–1.06 (0.19)***	1.18 (0.29)***	0.16 (0.17)	0.91 (0.31)***
Actual expenditures for R&D, mln rubles	0.12 (0.04)***	0.04 (0.02)*	0.008 (0.02)	0.02 (0.02)	0.01 (0.2)	0.004 (0.87)
Number of employed urban residents with higher education, thousand people		0.72 (0.07)***	–0.01 (0.12)	0.28 (0.11)**	0.44 (0.10)***	0.31 (0.01)***
Total IGP potential			0.76 (0.1)***			
Interregional IGP potential				0.58 (0.11)***		0.35 (0.01)**
Cumulative number of utilized patents from 1994					0.11 (0.04)***	0.07 (0.08)*
LSDV R2	0.91	0.92	0.92	0.92	0.92	0.92
Within R2	0.02	0.09	0.13	0.11	0.14	0.15
Schwarz's Bayesian Criterion (BIC)	2663	2575	2522	2553	2061	2058

Notes: LSDV – least square dummy variable model (LSDV) provides a good way to understand fixed effects. Within R2 is the R-squared from the mean-deviated regression. Significance of the coefficients in the regressions: * – 10 %; ** – 5 %; *** – 1 %. Standard errors in brackets.

where *Pat_rus* – the number of national patent applications, *Pat_PCT* – the number of PCT-patent applications. The coefficients in this case reflect degree of commerciability of different types of patents. It does not exceed 8 % for Russian and about 50 % for international patents, on average.

The hypotheses about the importance of expenditures for R & D according to the classical production function of knowledge [Griliches, 1979], human capital [Romer, 1990], international and interregional IGP and embeddedness of innovation systems (the number of technologies used previously) were tested in sequence. Table 2 shows the results of model estimation.

The models have quite similar parameters explaining the total variance, but poorly explain the patent output for a specific region (Within R^2). The best model was the one that simultaneously considered parameters of human capital, interregional IGP, and embeddedness. Calculation results of the econometric models show that the increase in the number and quality of human capital by 1 % leads to an intensification of the innovation output by 0.3–0.4 %, on average. At the same time, funding increase by 1 % increases output of new technologies by only 0.12 %. If a region's cumulative use of patents is up by 1 % compared to other regions, there are 0.07–0.11 % more potentially commercializable patents. If there are by 1 % more new technologies in neighbouring regions (interregional IGP), there are approximately 0.35–0.58 % more newly created technologies in the target region. The use of total IGP in models decreases the significance of other factors; its increase by 1 % in this case leads to an increase in the issuance of new technologies by 0.76 %.

CONCLUSION

The paper has demonstrated the importance of the geographical position in relation to major centres of new technologies development. Interregional innovation-geographical position is important for creation of new technologies due to the presence of knowledge spillovers, while for the diffusion of new technologies; proximity to major innovation centres has greater impact.

Employed urban population with higher education is a more significant factor of patent activity compared to R & D expenditures because financing may vary from year to year and may not be effective.

The process of regional innovation systems formation is long-term, because knowledge has a cumulative nature.

Potential interregional knowledge spillovers are significant in the models despite large distances between regions in Russia, and due to the concentration of patent activity in several regional clusters, between which active formal and informal knowledge exchange is taking place: Moscow, St. Petersburg, Siberia, Volga, and Ural.

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Appendix 1. Innovation-geographical position (IGP) of Russia's regions

Region	Inter-regional IGP in 2014	Growth of interregional IGP (2014/1998)	Interna-tional IGP in 2014	Growth of international IGP (2014/1998)	Total IGP in 2014	Growth of total IGP (2014/1998)
Kaliningrad region	0.58	1.6	84.68	1.89	85.27	1.89
Oryol Region	1.5	1.65	76.53	3.12	78.03	3.06
Primorsky Krai	0.1	1.84	76.54	5.09	76.65	5.07
The Republic of Karelia	0.88	1.52	60.29	1.8	61.17	1.79
Leningrad region	3.36	1.25	57.27	1.94	60.63	1.89
Saint Petersburg	0.96	1.71	57.27	1.94	58.23	1.94
Pskov region	1.19	1.49	54.3	2	55.49	1.98
Novgorod region	1.56	1.42	52.87	1.97	54.43	1.95
Moscow region	8.19	1.57	43.75	2.06	51.93	1.96
Khabarovsk region	0.12	1.7	50.74	4.03	50.86	4.02
Smolensk re-gion	1.42	1.6	49.07	2.03	50.49	2.01
Tver region	3.2	1.57	44.57	2.05	47.77	2.01
Jewish Autonomous Region	0.12	1.61	47.33	3.92	47.45	3.9
Kaluga region	2.9	1.58	44.08	2.06	46.98	2.02
Bryansk region	1.55	1.59	44.91	2.06	46.46	2.04
Vologda Region	1.27	1.62	44.47	2.07	45.74	2.05
Moscow	1.97	1.6	43.75	2.06	45.71	2.04
Tula region	2.35	1.59	43.17	2.07	45.53	2.04
Yaroslavl region	1.84	1.61	42.97	2.08	44.81	2.06
Arkhangelsk region	0.63	1.67	44.13	2.12	44.76	2.11
Murmansk region	0.41	1.64	43.96	2.11	44.36	2.1
Vladimir region	2.41	1.61	41.41	2.09	43.82	2.06
Ryazan Oblast	2.32	1.61	41.34	2.09	43.66	2.06
Rostov region	0.63	1.79	42.9	2.17	43.53	2.16
Kursk region	1.16	1.7	42.14	2.1	43.3	2.09
Kostroma region	1.56	1.68	41.6	2.09	43.16	2.07
Ivanovo region	1.93	1.65	41.14	2.1	43.06	2.07
Krasnodar region	0.55	1.73	42.43	2.19	42.98	2.18
Belgorod region	0.95	1.62	41.77	2.11	42.72	2.1
Lipetsk region	1.23	1.66	40.26	2.11	41.5	2.09
Voronezh region	1.12	1.64	39.91	2.12	41.03	2.11
Tambov Region	1.28	1.66	39.53	2.11	40.8	2.09

Continue Appendix

Region	Inter-regional IGP in 2014	Growth of interregional IGP (2014/1998)	Interna-tional IGP in 2014	Growth of international IGP (2014/1998)	Total IGP in 2014	Growth of total IGP (2014/1998)
Nizhny Novgorod Region	1.33	1.69	38.59	2.12	39.93	2.1
Stavropol region	0.53	1.74	38.89	2.2	39.42	2.19
Amur region	0.12	1.78	38.91	3.62	39.04	3.61
Republic of Adygea	0.52	1.77	38.39	2.2	38.91	2.19
Karachay-Cherkess Republic	0.53	1.79	38.04	2.2	38.57	2.19
The Republic of Mordovia	1.17	1.78	36.88	2.13	38.05	2.12
Volgograd region	0.7	1.73	37.02	2.19	37.72	2.18
Penza region	0.99	1.74	36.66	2.13	37.64	2.12
Kirov region	0.84	1.76	36.72	2.14	37.57	2.13
Saratov region	0.86	1.77	36.03	2.15	36.88	2.14
Kabardino-Balkar Republic	0.48	1.83	35.91	2.2	36.38	2.2
Republic of Kalmykia	0.45	1.77	35.87	2.21	36.32	2.2
The Republic of Ingushetia	0.58	2.09	35.66	2.2	36.24	2.2
Chuvash Republic	0.95	1.83	35.26	2.14	36.22	2.13
Republic of Tatarstan	0.94	1.83	35.09	2.14	36.04	2.13
Republic of North Ossetia-Alania	0.52	2.03	35.51	2.2	36.02	2.2
Sakhalin region	0.1	1.76	35.55	3.5	35.65	3.49
Mari El Republic	0.93	1.91	34.58	2.15	35.51	2.14
Chechen Republic	0.44	1.76	35.04	2.21	35.48	2.2
Ulyanovsk region	0.9	1.85	34.52	2.15	35.43	2.14
Komi Republic	0.55	1.73	34.84	2.17	35.39	2.16
The Republic of Dagestan	0.45	1.97	34.09	2.21	34.54	2.21
Samara Region	0.76	1.87	33.63	2.16	34.39	2.15
Udmurt Republic	0.75	1.93	33.03	2.17	33.78	2.17
Astrakhan region	0.54	1.81	33.14	2.2	33.68	2.19
Perm Krai	0.68	1.94	32.87	2.17	33.55	2.16
Nenets Autonomous Okrug	0.34	1.68	33.03	2.21	33.37	2.2
Orenburg region	0.59	1.87	30.83	2.18	31.42	2.17

Continue Appendix

Region	Inter-regional IGP in 2014	Growth of interregional IGP (2014/1998)	Interna-tional IGP in 2014	Growth of international IGP (2014/1998)	Total IGP in 2014	Growth of total IGP (2014/1998)
Sverdlovsk region	0.61	2.07	30.68	2.2	31.29	2.19
Republic of Bashkortostan	0.61	1.95	30.43	2.19	31.04	2.18
Kamchatka Krai	0.08	1.76	30.07	3.48	30.15	3.47
Chelyabinsk region	0.59	2.1	29.55	2.22	30.14	2.22
Tyumen region	0.55	2.05	29.27	2.23	29.82	2.23
Kurgan region	0.59	2.2	29.18	2.24	29.77	2.24
The Republic of Buryatia	0.19	1.94	29.08	2.8	29.27	2.79
Transbaikal region	0.17	1.88	28.85	3.07	29.02	3.06
Yamalo-Nenets Autonomous Okrug	0.34	1.72	28.64	2.22	28.98	2.21
Magadan Re-gion	0.08	1.77	28.3	3.4	28.38	3.39
Omsk region	0.46	2.27	27.6	2.3	28.06	2.3
The Republic of Sakha (Yakutia)	0.11	1.83	27.42	3.17	27.54	3.16
Novosibirsk region	0.35	2.15	26.54	2.41	26.89	2.4
The Republic of Khakassia	0.29	2.18	26.38	2.6	26.67	2.6
Irkutsk region	0.21	2.06	26.34	2.8	26.55	2.8
Tomsk region	0.43	2.63	25.99	2.45	26.42	2.45
Altai region	0.49	2.84	25.8	2.4	26.29	2.41
Kemerovo region	0.45	2.73	25.84	2.43	26.29	2.44
Krasnoyarsk region	0.3	2.26	25.95	2.55	26.25	2.55
Khanty-Mansi Autonomous District–Yugra	0.33	1.97	25.05	2.25	25.38	2.25
Altai Republic	0.36	2.42	24.9	2.4	25.26	2.4
Tyva Republic	0.24	2.08	24.81	2.58	25.05	2.58
Chukotka Autonomous Okrug	0.07	1.79	21.33	3.06	21.4	3.05

Received 08.09.2015 **Accepted 08.11.2016**

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DOI: 10.15356/2071-9388_04v09_2016_03

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LOW FLOW ON THE RIVERS OF THE EUROPEAN PART OF RUSSIA AND ITS HAZARDS

ABSTRACT. This paper reviews the changes in river flow of the European part of Russia during the low-flow period, characterizing groundwater flow feeding. River flow oscillations were analyzed for winter and summer periods. Statistical analyses of average low flow and the minimum monthly summer and winter discharges for 1946–1977 and 1978–2010 showed significant positive trends for all parameters of low-water period. The greatest increase is observed in the Middle Volga, where low flow has almost doubled.

The low flow discharges increased by up to 50–70 % in the center of the European part of Russia and the Upper Don and its tributaries, ranging from 0 to 30 % for the northern rivers. Despite the low flow increase, the lack of water in 2010 and 2014 caused economic damage. It is shown that the observed hydrological hazards occur as a result of snow melt draughts and water management instability.

KEY WORDS: low flow, lack of water, climate change, extreme hydrological events.

INTRODUCTION

Low flow period in the rivers of the European part of Russia occupies a large part of a year and determines the limits of water use in various sectors of economy. The increasing water needs for industry, agriculture, and population growth show more acute vulnerability of the society to the lack of water and draughts. That is why the questions related to low flow, flow distribution within the year, as well as the variability of these quantities are extremely relevant. Such studies are the basis for ecologically safe and economically effective use of water resources in Russia. The term "lack of water" can be interpreted as a period (on seasonal or long-term scale) of low river flow, having negative influence on economy. The lack of water is one of the dangerous hydrological phenomena. The number of extreme hydrometeorological events in Russia has nearly doubled from 1998 to 2013, according to the Federal Service for Hydrometeorology and Environmental Monitoring of Russia. In recent years, water shortages occurred in the basins of the Upper Volga and Oka (2010, 2014). Due to the low water levels in 2014, navigation was virtually stopped, which led to the multimillion losses in river tourism.

The lowest water level in the rivers of the European part of Russia is commonly observed in winter and in summer-autumn seasons. It is associated with the formation of low flow period – the phase of water regime, during which the rivers are almost completely fed by groundwater. The parameters of low flow period (usually the mean flow of 3 months in summer/winter), the minimum monthly or 30-daily values, as well as the flow of the shorter periods from 1 to 30 days, are often used in calculation and forecast of minimum flow in Russia and abroad [SP 33-101–2003, 2004]. The last comprehensive study of the minimum flow in Russia took place in the early seventies of the last century when "Surface water resources of the USSR" was published. The overall assessment of the minimum river flow and approaches to its study were conducted in the works of Vladimirov A.M. [Vladimirov, 1970, 1976]. The comprehensive cartographic generalization of the parameters of minimum river flow of the European part of Russia has not been carried out over the past period. The changes in the minimum flow of some river basins are reviewed in the works of Bolgov M.V. and Philippova I.A. [Bolgov et al., 2005; Bolgov, Philippova, 2014; Philippova, 2014]. An increase in low flow of the European rivers of Russia was proved and the areas of the low flow synchronic oscillations were isolated. The research by the State Hydrological Institute [Shiklomanov et al., 2010; Water Resources of Russia, 2008] showed that the observed increase in the low flow is absolutely unique in the history of hydrometric observations in Russia.

Thus, there is an urgent need to create modern maps of the low flow parameters, analyze the long-term dynamics of these indicators, and compare it with emerging extreme hydrological events.

The purpose of this work is to study spatio-temporal dynamics of the minimum flow of the European rivers of Russia, generalize observation data of low flow, and analyze extraordinary low flow periods and their causes. This paper is the result of the investigations carried out by a group of scientists of the Institute of Water Problems (Russian Academy of Sciences) and Lomonosov Moscow State University in 2013–2014 [Dzhamalov et al., 2013, 2014].

MATERIALS AND METHODS

There are more than 1500 gauging stations located in the European part of Russia, some of them have the observation series starting from the XIX century. Three hundred forty eight catchments were chosen to analyze objectively the conditions of zonal flow formation of different regions of the European part of Russia. Preference was given to medium-size rivers with the catchment area 5 to 20 thousand km^2 and characterized by natural flow. In some cases, the flow was estimated for the entire basin, as well as for its separate catchments. In this case, the parameters of flow were estimated as the difference of values between the outlet and the upstream cross section. The statistical parameters of the average low flow and the minimum monthly summer and winter flows were calculated for the selected representative catchments. At the same time, the low-water discharge was calculated as the averaged monthly discharges during the low flow period, which characterizes the groundwater feeding of rivers (Table 1).

Table 1. Terms of the lowest water level in the different river basins of the European part of Russia

Basin	Low flow period
North Dvina, Pechora, Mezen	XI–III
Volga	XII–II
Oka	XII–II
Kama	XII–II
Don	XII–II; VII–IX
Ural	XII–II; VII–IX

The calculations were carried out for three periods of 1945–2010, 1945–1977, and 1978–2010. This division was made due to several factors. Firstly, in this case the flow series were divided into relatively equal parts. Secondly, during the Second World War most of the gauging stations did not work and there was a break in the observations. The choice of 1978 as a turning point is supported by studies of many authors [Water resources of Russia, 2008; Bolgov et al. 2014]. In particular, during the last 30 years, the climate change has become statistically significant. According to the analysis of residual curves for 60 gauging stations, the trend of the low flow increase has been observed since 1978. The variety of values of the "turning point year" for various rivers of the European Russia is 5–7 years and it is highly dependent on each specific parameter. However, the period of 1978–2010 was assumed as representative for the up-to-date trends in the minimum flow changes. Thus, the comparison of the average values of the minimum flow for the previous stable period and modern period with its usual dynamics was made. The statistical treatment of the series was performed with the help of the program STATISTICA. The water discharge series were tested by mathematical expectation (Student t-test) and variance (Fisher's test), as well as by the presence of directional trend (nonparametric Spearman test). To analyze the temporal dynamics of extreme hydrological events, the annual values of shortage and excess of water resources were calculated on monthly data for 20 major line gauging stations. At the same time the monthly water discharges of 10 % and 90 % probability were assumed as "threshold values". In addition, the ratio of the shortage or excess of water to the duration of this period was calculated for each river.

RESULTS AND DISCUSSION

Low flow changes in different physical-geographical regions

At the beginning of the XXI century, the low flow of the majority of the European rivers of Russia increased, on average, by 40–60 % compared with the values until the mid-1970s (Fig. 1). Positive significant trends of winter and summer low flow increases characterize the Upper and Low Volga basins. The maximum change in low flow is typical of the forest-steppe zone, and is not associated with the increase in snow cover, but with the decrease in spring flow and its transformation into groundwater. The low flow increase by 70–100 % is observed in the same area, covering the basins of the Sura, Unzha, Vetluga, the lower reaches of the Kama and the Middle Volga. Southward on the flat part of the European part of Russia, the increase in low flow rapidly dissipates. And in the steppe regions of the Lower Volga and the Lower Don and the rivers of the Kuma-Manycheskaya depression, it fades away or is even slightly reduced (up to 5 %, which is not statistically significant). The reduction in the low flow growth rate also takes place northward and is associated with the line of the biggest changes.

Currently, the average proportion of the groundwater flow of the North European Rivers of Russia is ~30–40 % and it varies slightly for the rivers of the region. The significant increase in groundwater feeding, which in present-day conditions provides from 45 to 70 % of the total annual flow, is observed in the Volga basin (except the Kama). This is mainly due to the winter low-water increase. Roughly the same value of the groundwater flow proportion is typical of the upper reaches of the Don.

The flow increase in the low-water period is due to the growth of both winter and summer water discharges in the rivers of the southern slope of the European part of Russia (the middle and lower reaches of the Don, Kuban, Terek, etc.). This is due to the increased amounts of precipitation (Fig. 2). Changes in the average winter and summer low flows are relatively simultaneous, but with some time shift. The increase in the proportion of low flow in the annual runoff takes place with the decrease in average watershed altitude on the northern slopes of the Caucasus (the Terek, Kuban basins). The flattening-out of the

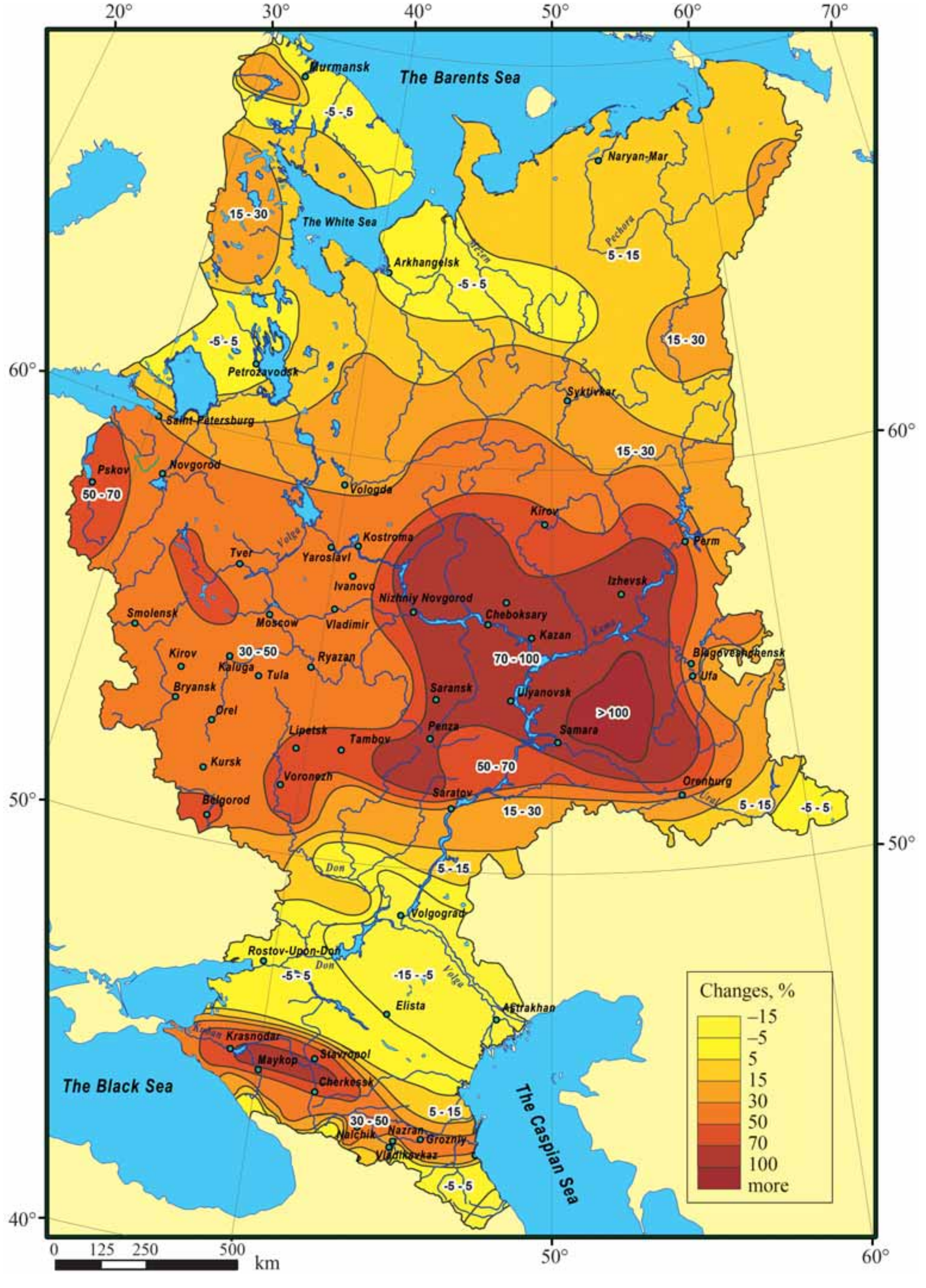

Fig. 1. Low flow changes of the European rivers of Russia

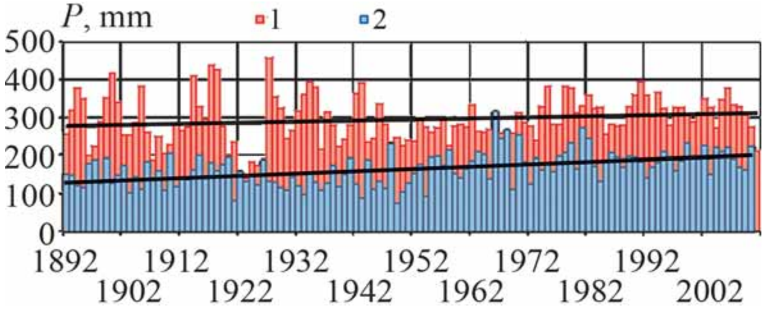

Fig. 2. Changes in precipitation during cold (XI–III) (1) and warm (IV–X) (2) periods for the Don River basin

low flow graph downstream the mountain river occurs under the increase in the area of low-altitude zone.

Groundwater flow in different climatic zones is formed by the so-called effective precipitation (seeping to the groundwater level). For the temperate zone of the European part of Russia it is usually the rainfall of winter-spring and autumn seasons. However, in the current climate conditions, the winter season is characterized by the increase in snow-rainfall flow which is formed from November to February-March due to frequent thaws. Close correlation (0.5–0.7) of groundwater flow of several rivers with the total November–April precipitations of the previous year was established. Compared with the precipitations of the current year, correlation has decreased to 0.3–0.4.

Average changes in the natural minimum resources for the summer and winter periods are 1–2 l/(sec • km^2). The maximum monthly yield (up to 2–3 l/(sec • km^2)) is typical for the northern regions. In the lower reaches of the Don and Volga rivers the minimum values decreased to 1 l/(sec • km^2) or less.

The minimum monthly flow in the northern rivers in the summer and winter periods varies from 15–25 % in the lower reaches up to 30–50 % in the middle reaches (the Northern Dvina and Pechora). The most significant increase in the minimum monthly water discharge (50–70 % and more) occurs in the upper reaches of the Oka, the middle reaches of the Volga, and in the Ural basin. The increase in minimum flow is less significant (15 %), up to its decline to the south from this line (the mouth and the middle reaches of the Don, the Ciscaucasia). However, in the upper reaches of the Don and its local tributaries, the increase in the minimum monthly water discharges grows again by 50–70 % (Fig. 3). The similar increase in the minimum flow is observed in the basins of the northern slopes of the Caucasus Mountains.

The maps constructed to compare ratio the minimum monthly discharges growth over the

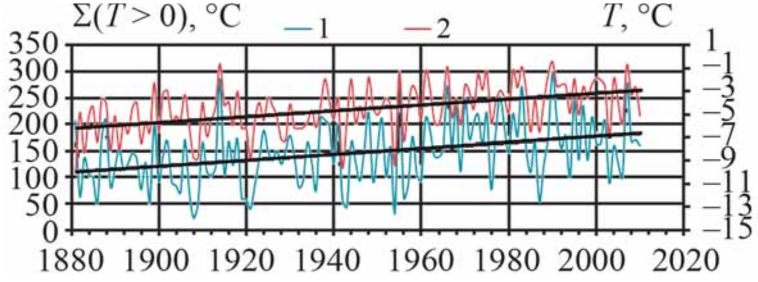

Fig. 3. Change in the above-zero (1) and average (2) temperatures during the cold (XI–III) period for the Don River basin

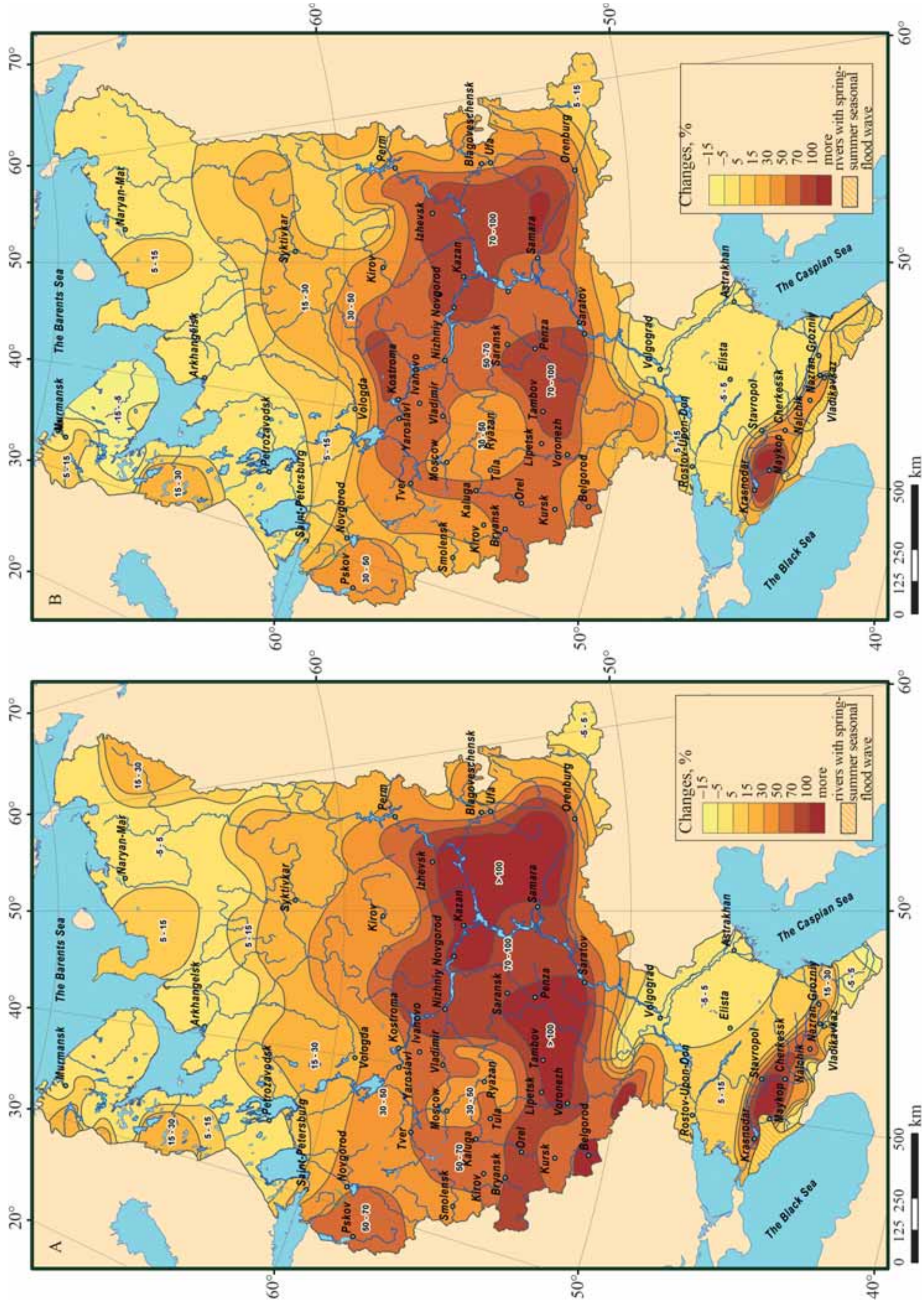

Fig. 4. Changes in the minimum monthly winter (A) and summer (B) flows

winter and summer periods (Fig. 4) show that the spatial variations of the minimum monthly winter and summer flows occur simultaneously. The growth of the minimum monthly winter discharge is by 20–30 % higher than the growth of the minimum monthly summer discharge almost everywhere. In the north and south of the European part of Russia the growth rate of summer and winter low flow is the same.

Intensive growth of winter minimum monthly discharges is associated with the number, duration, and depth of thaws. For example, for the twentieth century, the sum of positive temperatures during the winter period in the Don basin increased from 120 to 200 degrees. The average temperature of the winter period increased in the same way (see Fig. 3).

Long-term variability of low flow parameters and its hazards

The spatial analysis of low flow increase makes it possible to identify some specific regions with the similar low flow changes.

The entire Northern European part of Russia, in particular the Northern Dvina, Mezen, and Pechora basins, is a region with a statistically significant but relatively slight low flow growth. The period of the lowest water flow is observed here in winter – from December to March. The rest part of the year the wetness of the region is greater, frequent rain floods take place in summer. For the outlet gauging stations on major rivers the low flow changes are still statistically not significant (about 5–15 %) (Fig. 5 A). The relatively intensive

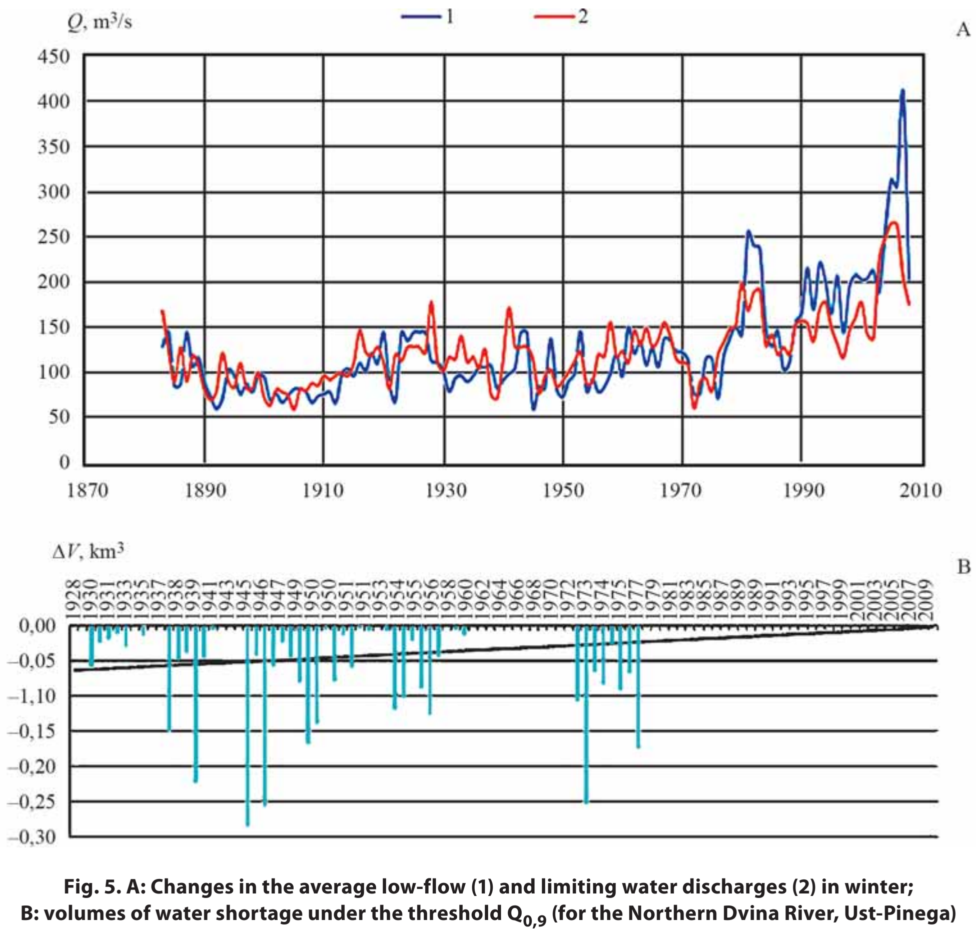

Fig. 5. A: Changes in the average low-flow (1) and limiting water discharges (2) in winter; B: volumes of water shortage under the threshold $Q_{0,9}$ (for the Northern Dvina River, Ust-Pinega)

positive trends are typical for the southern parts of the basins – the upper reaches of the major rivers and their tributaries. For example, the low flow increase of the Yug River ranges from 30–50 %.

The northern rivers are characterized by smooth reduction of the volumes of water shortage. The deepest water shortages occurred here in 1938–1945, and 1965–1975 were extremely high-water years. Water shortage periods were also observed on these rivers in the 2000s, but, for example, most of the water shortages on the Northern Dvina were observed in the 1930–1940s. Thereafter a steady decline in the frequency of water shortages started. The duration of water shortages, on the contrary, increased from 1–2 to 3 months, and sometimes up to 4, and the volume – decreased. Big water shortage was observed in 2002 after a long break (Fig. 5 B).

The greater increase in the low flow is observed in the Central Russia, in the basin of the Upper Volga and Oka. The statistically significant increase in both of the average low flow and the minimum monthly water discharges for the winter and summer is observed for most of the rivers. The growth of low-water discharges ranges from 30 to 70 % (Fig. 6 A). In addition, a pronounced recurrence is typical for low flow oscillations. A full cycle has the duration of about 30 years.

The extremely low water years were 1945, 1950, 1967–1969, and 1966, 1974, 1947–58 were high-water years in the Upper Volga

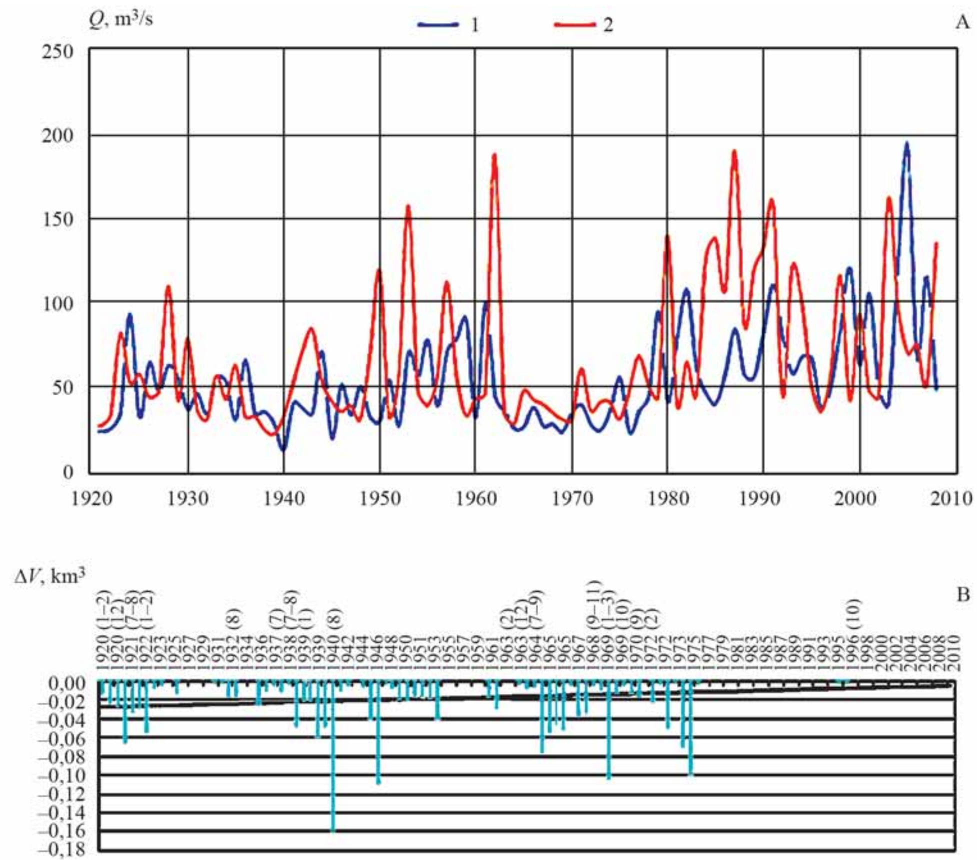

Fig. 6. Changes in the average low-flow water discharges (A) and volumes of water shortage under the threshold $Q_{0,9}$ (B) for the Volga River, Staritsa

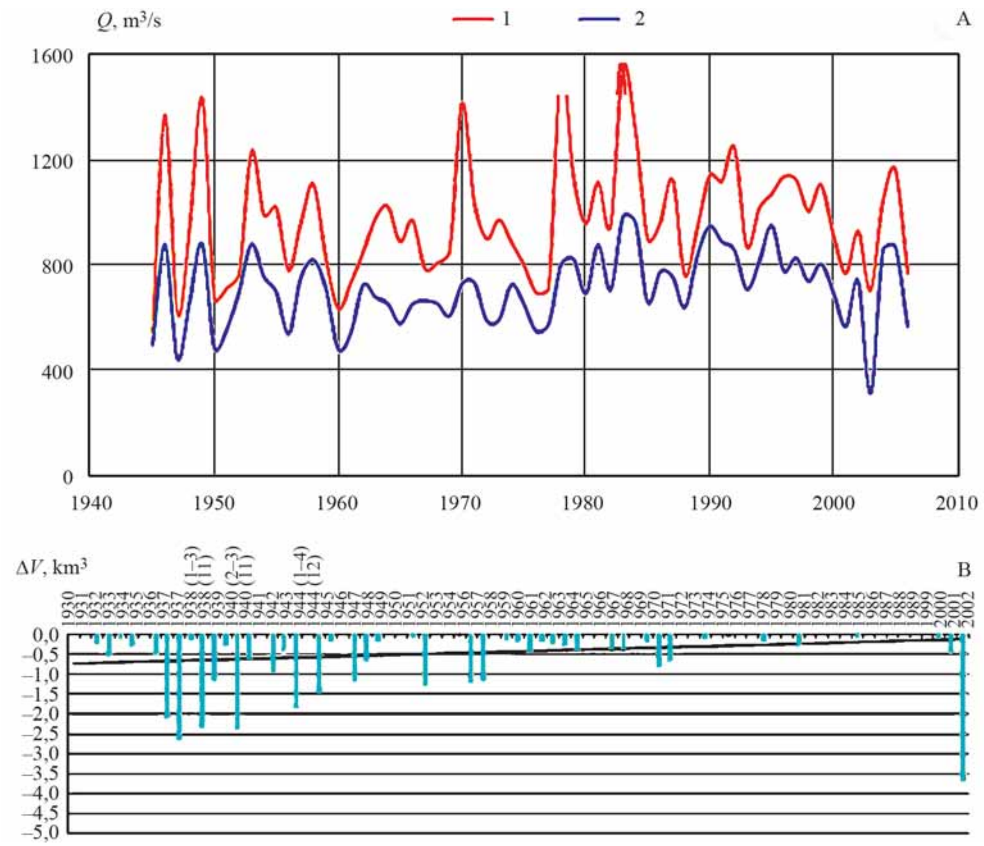

Fig. 7. A: changes in the monthly winter (1) and summer (2) water discharges; B: volumes of water shortage under the threshold $Q_{0,9}$ (for the Don River, village Kazanskaya)

basin. 1977 was the last year, when water shortage was observed (Fig. 6 B). The Volga tributaries have a somewhat different picture. The water shortages occurred mainly in 1937–1939, and the high-water period took place in 1958, 1970, 1979–1981 on the Oka, Ugra, Moksha, the last water shortages were observed here in 1973–1975 (except Moksha).

The trends similar to the North European part of Russia are observed in the eastern part of the region – in the Kama basin: there is a gradual decline of water shortage, the low-water period becomes shorter, and the flood period increases in volume. The greatest water shortages were observed here in the years of 1920–1940, and 1960–1970, and in the early 1990s were high-water years. Lack of water occurred here mainly in the years of 1920–1940. However, even in recent years (2006, 2008), as well as from 1976–1977, some water shortages also took place.

The most obvious changes were observed in the European south part of Russia, the Don and the Sura River basins. The greatest lack of water was recorded there in the late 1930's – early 1940's, as well as in 1972. Since 1975–1977, water shortages, in general, have ceased and have been observed only partially in the Don River tributaries in extremely low-water year of 2010 (Fig. 7).

Nevertheless, despite the increase in the low flow in 2010 and 2014, big lack of water was observed in summer. In 2010, it affected the basins of the Volga and Don and in 2014 – mainly the Upper Volga. The cause of water shortages was low moisture reserve in the

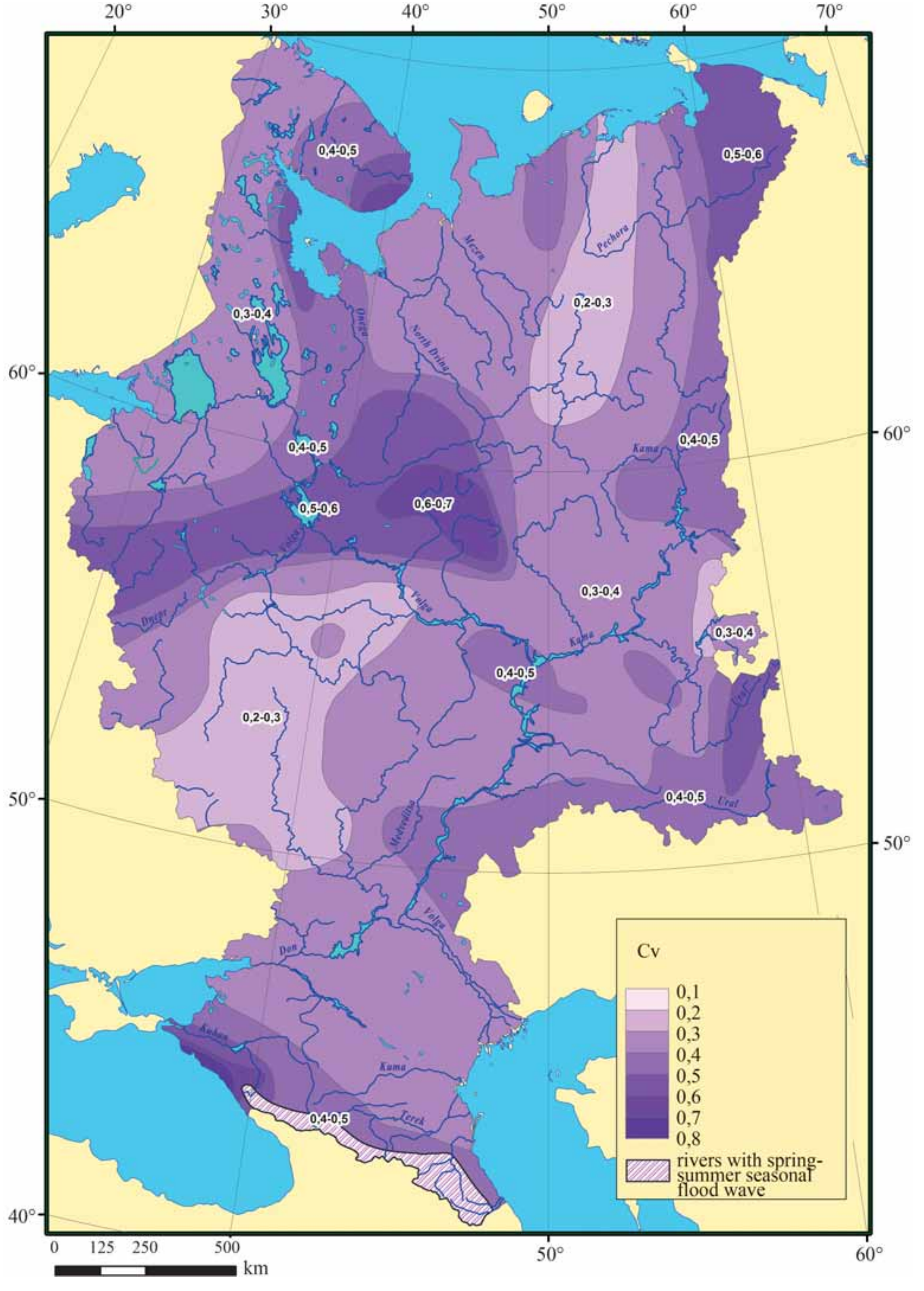

Fig. 8. Variation coefficient of the minimum summer flow in 1978–2010

snow cover at the end of spring, associated with numerous thaws and radiation evaporation of snow, the lack of rains in the spring-summer period, and abnormally hot weather. According to [Van Loon et al, 2014], in such a case it is advisable to emphasize a special type of draught – the draught arising from anomalous melting of snow (snowmelt draught). Under such conditions, the high-water period on the rivers is not practically observed. Flood flattens, has many peaks, and does not compensate the drained water storage in the basin during winter.

The variability of the minimum flow in summer significantly increases due to the alternation of anomalous and typical winters. For example, the highest values of variation coefficient of the minimum summer flow throughout the European part of Russia, ranging from 0.5–0.7, occur in the Upper Volga basin (Fig. 8). High values of C_V were also observed on the Kola Peninsula, in the basins of the Onega and Pechora Rivers, ranging from 0.4–0.5. Summer precipitation is strongly dependent on the North Atlantic cyclones and it is a highly variable process. High variability of the minimum summer flow is also observed in the basin of the Ural, which is subjected to spreading of the dry air masses from Central Asia.

CONCLUSION

The increase in water content in low-water has taken place due to the impact of climate change in the past 30 years on most of the European part of Russia, being unique throughout the history of hydrometric observations. These changes are different in various physical-geographic regions. The most intensive increase in the low flow occurs in the basin of the Middle Volga, where the low water discharges almost doubled (by 70 % or more). The low flow increases rather intensely in the western rivers of the Upper Don and its tributaries – the Khoper and Medveditsa, in the basin of the Upper Volga (up to 50–70 %). Slightly less intensive growth (30–50 %) is observed in the large territory from latitude 52 to 60 °N. Almost the whole Central Russia and the upper reaches of the Northern Dvina and Kama are situated in this zone. The smallest increase of the low flow is observed in the North European Russia in the basins of the Mezen, Pechora, middle and lower reaches of the Northern Dvina Rivers, as well as in the south – between the Lower Don and the Volga, the rivers of the Kuma-Manycheskaya depression.

The low flow growth occurs due to increase of the summer and winter (by almost 1.5 times more intensely than the summer) water discharges. Frequent thaws, the overall increase in rainfall, both for summer and winter, the reduction of the depth of freezing and, in general, favorable conditions for infiltration, increased groundwater feeding are the main factors of the low flow growth. The number of water shortage periods is reduced. They become less harsh and more prolonged on most of the rivers of the European Russia. The average duration increased from 1–2 months to 3–4 months. In most of the rivers in Central Russia, the frequency of water shortages ceased at the end of the 1970s. Despite the overall reduction in water shortages, the lack of water in the Central part of Russia and the Volga and Don basins was observed in 2010 and 2014. Small water storage in the snow cover, spring radiation, frequent thaws, abnormally hot summers, and extremely low floods caused the lack of water.

All these factors in spring prevent river basins from water renewal; the draughts take place because of the lack of snowmelt water (snowmelt draught) [Van Loon et al, 2014]. Variation coefficient of the summer flow greatly increases in such conditions. Moreover, just for the Upper Volga it is maximal and reaches 0.5–0.7.

ACKNOWLEDGMENTS

The study is financially supported by the Russian Foundation for Basic Research (Proj. № 16-35-60080), and the Russian Science Foundation (Grants NNo. 14-17-00155 and 14-17-00700) for calculations and data. ■

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Received 01.07.2016 **Accepted 08.11.2016**

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DOI: 10.15356/2071-9388_04v09_2016_04

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WARMER URBAN CLIMATES FOR DEVELOPMENT OF GREEN SPACES IN NORTHERN SIBERIAN CITIES

ABSTRACT. Modern human societies have accumulated considerable power to modify their environment and the earth's system climate as the whole. The most significant environmental changes are found in the urbanized areas. This study considers coherent changes in vegetation productivity and land surface temperature (LST) around four northern West Siberian cities, namely, Tazovsky, Nadym, Noyabrsk and Megion. These cities are located in tundra, forest-tundra, northern taiga and middle taiga bioclimatic zones correspondingly. Our analysis of 15 years (2000–2014) Moderate Resolution Imaging Spectroradiometer (MODIS) data revealed significantly (1.3 °C to 5.2 °C) warmer seasonally averaged LST within the urbanized territories than those of the surrounding landscapes. The magnitude of the urban LST anomaly corresponds to climates found 300–600 km to the South. In the climate change perspective, this magnitude corresponds to the expected regional warming by the middle or the end of the 21st century. Warmer urban climates, and specifically warmer upper soil layers, can support re-vegetation of the disturbed urban landscapes with more productive trees and tall shrubs. This afforestation is welcome by the migrant city population as it is more consistent with their traditional ecological knowledge. Survival of atypical, southern plant species encourages a number of initiatives and investment to introduce even broader spectrum of temperate blossoming trees and shrubs in urban landscapes. The unintended changes of the urban micro-climates in combination with knowledgeable urban planning could transform the Siberian pioneer settlements into places of belonging.

KEY WORDS: Surface urban heat island (SUHI), traditional ecological knowledge (TEK), urban green spaces, satellite data analysis, MODIS, NDVI, Siberia.

INTRODUCTION

Urbanized territories represent significantly, or even entirely, anthropogenic environment. Anthropogenic modification of some environmental features, such as landscapes, land use types and air quality, is obvious to any observer. Changes in other environmental features are less apparent. For instance, the vegetation productivity and land surface temperature (LST) changes, considered in this study, could be quantified only through statistical analysis of meteorological data and satellite images.

It is even more difficult to establish unambiguous links between socio-economic, ecologic and physical environments. A straightforward causality approach, from which natural sciences benefit, is usually not fruitful in such studies. Almost any author points to some connections between the physical environment and social aspects of the urban life [e.g. Brown and Raymond, 2007; Barthelet al., 2010; Buyantuyev and Wu, 2010; Wolfe and Mennis, 2012; Hebbert, 2014]. At the same time, the statistical support, aside from the deterministic models, for the proposed constructs remains weak. Boundaries between categories are often unclear and important nuances pertain.

Nevertheless, there is a growing understanding that the urban development should take into account interplay between the environmental and social forces. For instance, a sociological study from Svalbard [Kaltenborn, 1998] found that environmental impact assessments often do not capture a sufficient breadth of qualitative environmental meanings intrinsic to the migrants' groups. Cultural values of the urban migrants' groups are influential factor in the decision making process [Stephenson, 2008]. Those groups possess both technologic and policy strength, but the groups' cultural values may not fully account for the limiting climate and ecosystem resources. This dissonance could be particularly challenging in new pioneering settlements where people rely on their incompatible traditional ecological knowledge (TEK) in solving the environmental issues. Although rather blur and to some degree internally inconsistent [Whyte, 2013], the TEK concept has been shown useful in adaptive environmental management [Berkes et al., 2000]. McBride and Douhovnikoff [2012] study gives an example of the migrants' TEK in action. They show that high symbolic and cultural values of trees drive significant efforts for urban afforestation and creation of urban green places in polar cities with climates as harsh as in Nuuk (Greenland).

Similar dissonance in the social-environmental interactions characterizes the northern West Siberia (NWS) cities. Intensive exploration of the oil and gas reserves drives migration from the temperate climate zone to new urban centers in the cold continental climate zone. As the natural landscape in the NWS is valued rather low in the migrants' TEK, the urban development went along with significant damages to the natural vegetation cover, soils and hydrological systems. Wide use of sand in urban development modified thermal features, albedo and moisture content of artificial urban soils. As we show in this study, high albedo of urbanized territories is effectively counterweighted by other physical factors leading to elevated averaged LST in the cities. This is in dramatic contrast to the reported albedo-dominated feedbacks in the cities of lower latitudes (e.g. Jin et al., 2005]. The albedo-vegetation feedback is also contrasting in high latitudes. Li et al. (2015] found that boreal forests have strong warming effect in winter and moderate cooling effect in summer with net warming annually. Thus, the NWS cities have warmer micro-climate, which helps afforestation and survival of introduced more southern and more productive tree species (Srodnykh, 2008], and vice versa, the urban afforestation and green spaces might support warmer micro-climates in cities. We reveal that vegetation productivity in and around the cities is increasing, perhaps as a response on the warmer micro-climates.

The introduction of temperate blossoming plants is welcome by the migrants' population. Although the cold climate vegetation remains biologically inactive during the largest part of the year, it still changes the aerodynamic and thermal resistances of the lowermost atmospheric layer, surface emissivity and albedo as well as soil characteristics. Beyond the physical impact of vegetation, growing empirical evidence indicates its impact on population health and lifestyles, eventually contributing to the population psycho-physiological comfort (Zrudlo, 1988; Nikolopoulou and Steemers, 2003]. Urban green spaces serve as places of identity and belonging. They provide important social and psychological benefits enriching human life and emotions. Those benefits might be as important to urban sustainability as more recognized recreation and protective services of the green spaces (Royet al., 2012]. Indeed, sociological studies in Niznevartovsk [Vyhodzev, 2010] demonstrated that a lack of urban green spaces was an influential factor degrading the perception of sense of place and ecological perspectives among the city dwellers. Only 40 % of the respondents in this city considered it as the place of permanent residency in 2009. This is a considerable decline from almost 80 % reported in 1989.

Although far from being exhaustive, the reviewed literature highlights the high cultural value and psychological benefits of urban green spaces. Creation of "sense of place" and green spaces in the NWS cities is more difficult and requires more resources than similar development in lower latitudes. The major vegetation limiting factor here is the cold climate with its low winter temperatures and a short growing season [Barichivich et al., 2014]. Another frequently cited limiting factor – soil moisture – may have an impact on the vegetation surrounding the cities, but the tended urban vegetation is likely to be insensitive to it.

The warmer urban soils and the warmer surface air layers could significantly alleviate constraints imposed by the low temperatures. The systematic temperature difference between the urban and the surrounding rural locations are known in literature as the urban heat island (UHI). UHI is usually related to the air temperature. Therefore, we distinguish the surface urban heat island (SUHI) in the study of the LST contrasts. There are several publications reporting warmer UHI in the polar cities [Magee et al., 1999; Hinkel and Nelson, 2007; Klene et al., 2013; Konstantinov et al., 2015]. Wienert and Kuttler [2005] found that the UHI amplitudes increase towards high latitudes. The dependence could be explained by trapping and accumulating the additional anthropogenic urban heat in shallow stably stratified atmospheric boundary layer [Davy and Esau, 2016]. Neither UHI nor SUHI were studied in the NWS cities. Sparse in situ observational networks do not allow UHI identification. Moreover, many existing stations of the WMO network are located at airports, thus making the data unsuitable, as we will show here.

The subsequent presentation consists of three parts. The next section describes the data and methods followed by the section reporting the results. These sections comply with the quantitative rigor of the natural earth's system science. The last section presents discussion and conclusions. Here we attempt to bridge with the Stedman's [2003] interpretation of the physical environment as a key element of the social "sense of place" construct.

DATA AND METHOD

The UHI amplitudes are usually calculated from in situ meteorological observations both at regular certified stations and increasingly at irregular networks of citizens' observations [Meier et al., 2015]. Nevertheless, even dense citizens' observation networks do not cover the diversity of urban micro-climates as they tend to concentrate in residential areas leaving urban green spaces without coverage [e.g. Moelders and Olson, 2004].The regular networks are sparse so that pairing of urban and rural stations is difficult [e.g. Mishra et al., 2015]. In the considered NWS cities, such pairing was impossible. There were no self-identified urban stations and only three airport stations are included in the regular WMO network in the NWS.

A new perspective on the urban heat islands is provided by the hyperspectral Moderate Resolution Imaging Spectroradiometer (MODIS) system, channels 31 and 32 (10.78–11.28 and 11.77–12.27 micrometers, respectively) onboard of Terra and Aqua satellites. We used two MODIS data products. The level-3 MODIS global LST 8-day data (MOD11A2) are composed from the daily 1-kilometer LST product (MOD11A1) and stored on a 1-kilometer Sinusoidal grid (SIN) as the average values of clear-sky LSTs during an 8-day period. The further processing of these data products was similar to the processing of a Normalized Difference Vegetation Index (NDVI) data. Therefore, we describe below only the NDVI data processing from Esau et al. [2016] and Miles and Esau [2016].

LST data characterize SUHI. The LST is related to the surface air temperatures but may have considerable deviations in the seasonal and diurnal cycles, since they are more sensitive to the surface energy balance and less to the turbulent exchange in the overlying atmosphere [Gentine et al., 2010].

Schwartz et al. [2011] used MODIS LST products for 2002–2003 to study the SUHI and its relations with other eleven urban heat island indicators in 263 European cities. They found that time series of SUHI and other indicators individually reveal diurnal and seasonal patterns but show rather low correlations over time, although they were constructed to quantify the same phenomenon. Recently, Konstantinov et al. [2015] compared the MODIS LST and the spatially distributed direct observations of the surface air temperatures in the city of Apatity. They concluded that the air temperature calculated according to the MODIS data is systematically higher under winter conditions than the air temperature from direct measurement data.

To identify permanent thermal anomalies associated with urban areas we used the Terra/MODIS Land surface temperature (LST) data from 2001 to 2015. Land surface temperature and emissivity product, MOD11A2 of Terra-MODIS has been used in the study. MOD11A2 is an eight-day LST product by averaging from two to eight days of the clear sky MOD11A1 daily product of Terra-MODIS and has 12 Science Data Sets (SDS) layers [Li, 2013]. It has high calibration accuracy in multiple thermal infrared bands designed for retrievals of LST and atmospheric properties [Wang, 2008]. A split-window algorithm is used for calculating LSTs. The day/night LST method retrieves land-surface temperature and band emissivity simultaneously from pairs of daytime and nighttime MODIS data in seven TIR bands.

LST composites were downloaded from http://reverb.echo.nasa.gov/. The downloaded data is in HDF-EOS format and in SIN Projection System. The data were re-projected to UTM Zone 42N projection system with WGS84 datum and were reformatted from HDF-EOS to GeoTIFF format and converted from Kelvin to degree centigrade. According to the product quality control flag, the data we used have an average LST error less than or equal to 2 °C. We process day and night LST data. For Terra/MODIS the satellite overpass time is approximately 10:30 and 22:30 local time.

For each city, we compute annual mean LST per pixel by aggregating the available 8-days-mean composite separately for winter and summer. The mean values were calculated based on the 14 year time series. As a result we produced temporally average summer and winter LST map for each city. To compute SUHI magnitudes, we identified urban and rural pixels. Urban pixels were allocated by the city polygon; the surrounding, non-urban land, was considered as rural. Rural pixels are classified as natural surfaces such as different type of forest and non-forested areas.

The changes in vegetation productivity are characterized using the maximum annual NDVI (NDVImax). NDVI is defined as a normalized ratio of reflectance factors in the near infrared and red spectral radiation bands. NDVI is based on the contrast between red and near infrared reflectance of vegetation, as chlorophyll is a strong absorber of red light, whereas the internal structure of leaves reflects highly in the near infrared. Vegetation produces positive NDVI and approaches + 1 with increasing plant chlorophyll content or green biomass. The tiles of the original data products were downloaded and imported into the ArcGIS geographic information system (GIS). Images were reprojected to the universal Transverse Mercator projection (UTM Zone 42N, WGS84 ellipsoid). The data were quality-filtered by the MODIS reliability data provided together with the products, to retain only data of the highest quality. The gaps in the raster pixels were filled with information using the nearest neighbor statistical interpolation from the surrounding pixels with data. The percentage of excluded pixels is variable, ranging from 10 %–30 %. The NDVI values below 0.2 are generally non-vegetated surfaces and green vegetation canopies are generally greater than 0.3. A 0.3–1 NDVI threshold was used to exclude water, bare soil and other non-vegetated pixel from the analysis.

We use annual maximum NDVI (NDVImax) in this study. NDVImax values characterize the maximum development and represent the peak greenness achieved by vegetation during the growing season. Summarizing

NDVI into NDVImax composites eliminates any seasonal variation in NDVI and reduces the errors in beginning of phenological phases between different vegetation zones. An NDVImax map for each year (summer, JJA) was compiled by selecting the maximum NDVI value from each 16-day composite for each pixel. This results in a 250 m resolution, 15-year dataset of NDVImax and generated an up-to-date 15-year mean NDVImax map throughout NWS. We do not analyze here the NDVI data for the winter period.

The MODIS NDVImax and LST data for the 2000–2014 summers (June–July–August, JJA) and winters (December–January–February, DJF) were computed across the entire NWS area. For the specific purpose of this study, the data were clipped in 40 x 40 km squares centered at the four cities. The cities are Tazovskiy, Nadym, Noyabrsk and Megion.

Statistical methods were applied to the time series in order to provide metrics and to identify and test for changes. Time series characteristics of interest are the seasonal means for the LST and trends for the NDVImax. The linear trends in NDVImax were obtained for the period 2000–2014 through the Ordinary Least Squares (OLS) regression for each pixel stack, with year as the independent variable and NDVImax as the response variable. The purpose is to do a pixel-wise trend analysis and extract only significant trends over a certain period of time for rejecting the null hypotheses. To identify pixels with statistically significant trends, we masked out all pixels with an estimate p-value >0.05.

RESULTS

This study considers four NWS cities (Tazovskiy, Nadym, Noyabrsk, and Megion) located in four bioclimatic zones such as tundra, forest-tundra, northern and middle taiga, correspondingly. Table 1 summarizes the city characteristics. The MODIS-based climatology reveals that all four cities have significantly modified LST and vegetation cover. Figure 1 shows that warmer mean seasonal temperatures are found in the urbanized areas. The strongest and the most localized SUHI is found in Noyabrsk. The LST maps need some comments. All four cities are surrounded by very sparsely populated areas. There are no sub-urban or rural settlements there. Nevertheless, one can observe that the spots of warmer LST are found not only within the cities but also around them. Most of those spots are identified as lakes, large rivers and, in summertime, patches of drier sandy soils. There are also many industrial installations and locations of drilling platforms, particularly around Megion. The detailed analysis of these warmer spots is beyond the scope of this study.

Urban development destroys the natural vegetation cover. In addition, many northern cities are built on the artificial sandy ground that is higher than the surrounding landscape and therefore better drained. Distortions of the established cold-conserving ecosystems [Archegova, 2007], better drainage and anthropogenic heating (up to 50 $W \cdot m^{-2}$) create favorable conditions for reclaiming the urban land disturbances by broad-leaf and dark-needle trees and other more southern plant species [Lloyd et al., 2003; Koronatova and Milyaeva, 2011]. However, except for the northernmost city of Tazovskiy, no significant correlation between the NDVImax and LST was found. Perhaps, we observe here the effect of lacking nutrients in the sandy soils as it has been pointed to in [Srodnykh, 2008]. More detailed analysis revealed that there is a productivity decline in all types of forests except that in larch forest in the tundra-forest zone (Nadym). The patches of unforested area do demonstrate statistically significant greening, i.e., increase of vegetation productivity. This urban greening is particularly interesting to observe in the southernmost city of Megion where the surrounding vegetation shows no NDVImax changes or even widespread significantly negative trends.

The city of Nadym is of specific interest here. Figure 1 shows the mean seasonal LST patterns

Table 1. Four cities in Western Siberia included in the study. The city population (pop. in thousands inhabitants) is given from the Russian national census, 2010. The mean background *NDVImax* (nature) is shown for the most distant 40-km ring. The relative trends are given for the time series without the years with the minimum and maximum *NDVImax*. Statistically significant trends at 95 % level are underlined. The biomes are abbreviated as: tundra (T); forest-tundra (FT); northern taiga forest (NTF); and middle taiga forest (MTF). The analysis is based on 2000–2014 (15 years) climatology

N	City Name	Lat. Long.	Pop. (×1000)	Biome	UHI [K] Summer	UHI [K] Winter	Mean NDVImax (nature)	NDVImax trend (nature) [% dec^{-1}]	Mean NDVImax (city core)	NDVImax trend (city core) [% dec^{-1}]
1	Tazovskiy	67°28′N 78°42′E	↓7	NTF	0.3	0.8	0.73	+1.5 %	0.63	**+7.6 %**
2	Nadym	65°32′N 72°31′E	↓46	NTF	1.3	1.8	0.71	+1.2 %	0.55	–1.8 %
3	Noyabrsk	63°11′N 75°27′E	↓107	MTF	3.2	2.7	0.69	No change	0.60	+0.6 %
4	Megion	61°22′N 76°06′E	↓49	MTF	1.3	1.6	0.77	+0.8 %	0.52	**+6.9 %**

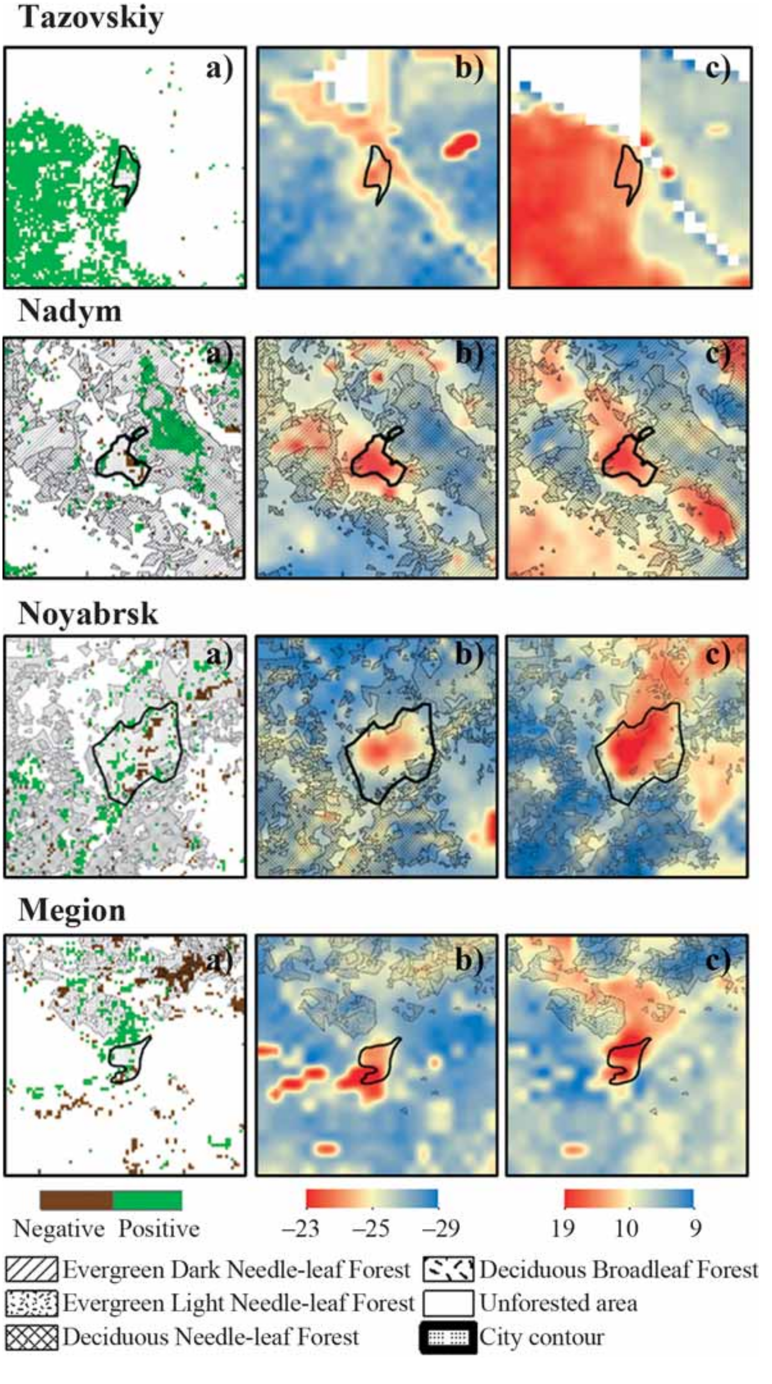

Fig. 1. Maps of four cities situated in different bioclimatic zones of the northern West Siberia: tundra (Tazovskiy); forest-tundra (Nadym); northern taiga (Noyabrsk); and middle taiga (Megion).

The panels (a) show the statistically significant NDVImax trends. The panels (b) and (c) show the seasonally averaged LST for the winter (DJF) and summer (JJA) seasons, correspondingly. The bold black contours identify the city boundaries. The different vegetation types [Bartalev et al. 2014] are shown with hatching.

around Nadym. The winter warmer spots are mostly localized within the city boundary. This is consistent with active anthropogenic heat release in the city. The summer warmer spots are more widely distributed. A strong warmer spot emerges to the southeast from the city. Figure 2 details the mean summer LST pattern around Nadym. The reader can observe that a summer seasonal warmer spot is associated with the Nadym airport. The airport area is a vast barren soil and sand area as the Google Earth image in the collage shows. One can observe that the meteorological station Nadym (WMO code 23445) is found within the warmer spot in summertime. The airport warmer spot disappears in wintertime. It helps to distinguish between the direct anthropogenic urban heating, which creates the Nadym SUHI, and the indirect heating induced by the surface energy balance changes due to drier barren and sandy soil, which creates the airport SUHI due to reduced heat consumption on evapotranspiration. Longer field studies summarized by Moskalenko [2009] reveal the permafrost and vegetation changes in Nadym in 1970–2008. The human-induced terrain disturbances were reclaimed by plant communities of birch (*Betula nana*), pines (*Pinus silvestris, P. sibirica*) and tall shrubs, which are more typical of northern taiga ecosystems further south from this area. The statistically significant increase of the NDVImax (greening) is found for all vegetation cover types around the city. Although the most pronounced greening in the larch (*Larix sibirica*) forest is likely unaffected by the SUHI, the greening of the urban green spaces is found in the areas where the annual mean SUHI reaches 4–5 K.

Similar SUHI and NDVImax trends patterns are found around Noyabrsk. The urban greening is widespread in this city and around the airport. The airport SUHI has smaller magnitude, presumably because it occupies smaller area and does not have such a strong soil moisture contrast with the surrounding territory.

We further studied the mean NDVImax and its trends in eight 5-km wide rings around the city cores. Figure 3 shows that the ring closest to the city, and therefore the most affected by the SUHI but only insignificantly disturbed by the direct human activity, has higher NDVImax than the more distant rings. This NDVImax difference is statistically significant

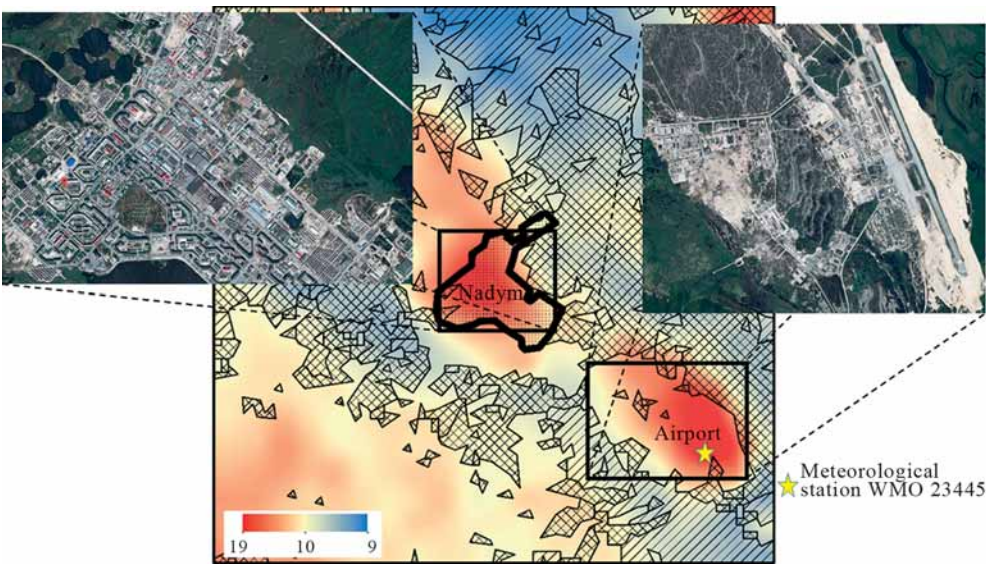

Fig. 2. The mean summer LST (color scale) and the vegetation cover types (the same as in Fig. 1) around Nadym and the Google Earth© images of the two selected warmer spots.

The meteorological station Nadym (WMO nr. 23445) is located within the summer seasonal warm spot at the airport.

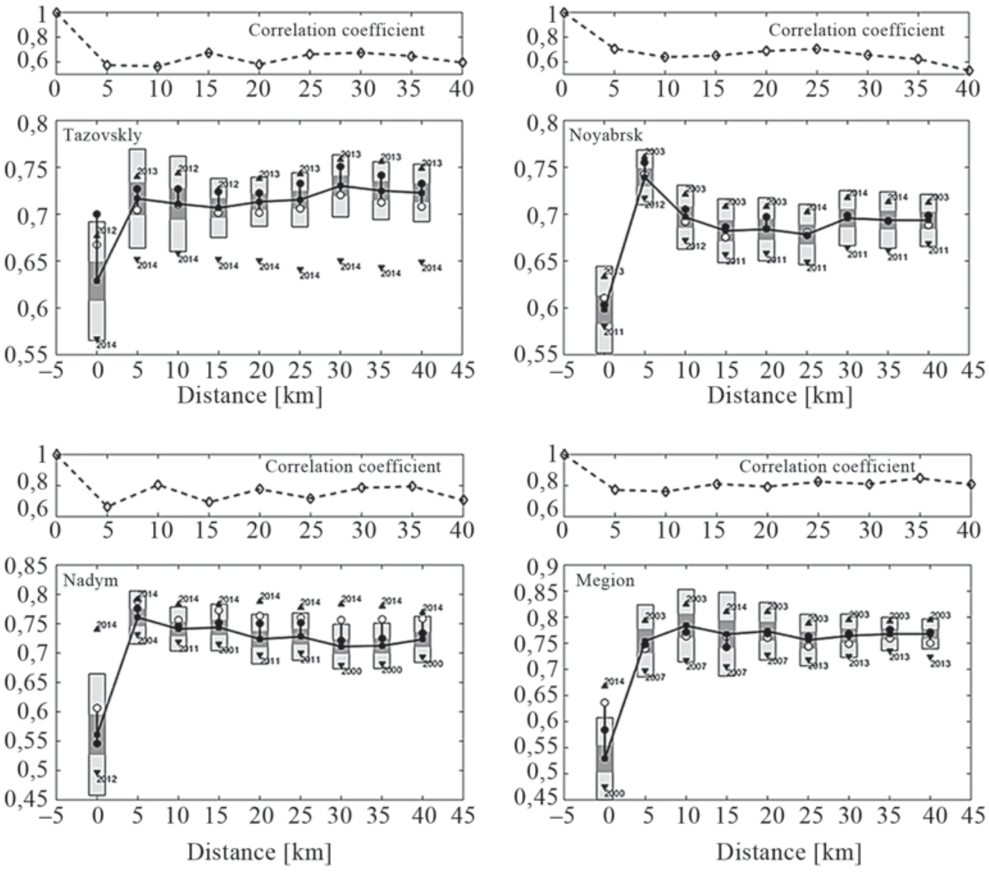

Fig. 3. The statistical structure of NDVImax, correlations and trends at the city-core and the eight 5-km wide rings around Tazovskiy (tundra), Nadym (tundra-forest), Noyabrsk (northern taiga) and Megion (middle taiga).

The distance is given in kilometers from the central pixel of each city. The upper panels for each city show the decay of time series correlations (extreme years were excluded from the calculation to improve robustness of the parameter estimation) between the NDVImax at the city core and at the given distance. The lower panels show: bold line with squares – the mean NDVImax; dark gray rectangle – 1 standard deviation of NDVImax for each ring; light gray rectangles – 3 standard deviations; triangles – the years with the maximum (upward-looking triangle) and the minimum (downward-looking triangle) of NDVImax; vertical black line with white circle – the magnitude of the NDVImax change obtained as the trend multiplied by 15 years; black circle – the same as the white circle but for the trends obtained when the maximum and the minimum NDVImax were excluded.

($p < 0.05$) in Noyabrsk. Both the cities and the first rings around them exhibit larger positive NDVImax trends than the surrounding natural vegetation. This difference is however statistically insignificant as the sample size (15 years) is too small. Figure 3 also includes the outliers in the years of maximum and minimum biological production. It is interesting that the anomalously cold summer in 2014 resulted in the maximum NDVImax in Nadym, but in the record minimum NDVImax further east in Tazovskiy.

DISCUSSION

One of the aims of the physical environment studies is to gain robust and quantitative knowledge for sustainable development of the human societies. Arguably, such knowledge is in particularly large demand in migrant societies where the intuitive TEK of the members becomes unreliable or at least insufficient. If the industrial development and resource extraction are purely driven by technologically optimized solutions, the created living environment becomes destructive to the human aspects of life such as those collectively described as sense of place. Sense of place interlinks the physical environment, human behaviors, preconditioned by the groups' TEK, and social/psychological processes [Stedman, 2003).

In majority of publications the physical and human environments are still considered independently. As a relevant example, one can use the studies of urban forest, urban air pollution and urban green spaces in general. It was argued that the main service of the urban green spaces is to provide protection from the physical (wind, direct solar radiation) and chemical factors. However, the polar vegetation is inactive during the largest part of the year; its growth is limited by the cold climate, and therefore, its environmental services are inefficient. Moreover, the LST – vegetation feedbacks, particularly on climatic time scales, are not firmly established. Li et al. [2014] study suggested that the boreal forest effect leads to strong winter (and the annual mean) warming and moderate summer cooling. Contrary, our results show that the larch forest remains significantly colder than the open green spaces even in wintertime (see Fig. 2).

There are a growing number of publications (see Introduction) where the accents are shifted onto social services of the green spaces. For instance, it has been shown that the green spaces improve the health perception much more than they actually can improve the air quality [Kardan et al., 2015]. One of the first policy moves in the NWS cities when they were converted into the permanent settlements was to establish the green planning and nature conservation initiatives [Srodnykh, 2006]. The migrants' TEK connects the green spaces and the living comfort and encourages different forms of green planning even those involving significant time, administrative and financial resources[1]. More recently, municipal administrations have raised investment into experiments with more southern plant species and even fruit trees[2]. The population attitudes towards the permanent residency dramatically degrade in the cities where such initiatives were delayed [Vyhodzev, 2010].

It has been shown that the urban migrants' groups have intrinsic cultural and TEK attachments to trees [McBride and Duhovnikoff, 2013]. The vegetation communities in the cold Siberian climate are limited both in number of tree species and in their biologic productivity. Recently, Miles and Esau [2016] demonstrated that the forest in the NWS reveals widespread negative biological production trends. But those trends are found to be reduced or even reverted around 28 cities in this region [Esau et al., 2016]. We put forward a hypothesis that the urban-background differences in the forest productivity could be linked with the higher LST and drier soils in the NWS cities as well as with denser stand and different composition of species of the urban forested patches.

This study considered the remotely sensed mean seasonal LST and NDVImax climatology (2000–2014) in and around four cities. We found that all four cities are associated with the warmer LST spots in both winter and summer seasons. The summertime SUHIs vary from +1.7 °C in the smallest and the northernmost city of Tazovskiy to +5.2 °C in the largest city of Noyabrsk. The wintertime SUHIs vary from +1.3 °C in Tazovskiy to +3.9 °C in Noyabrsk. Thus, this sub-sample of the NWS cities suggests that the SUHI strongly depends on the city size.

The vegetation productivity is modulated by the city policy towards the green spaces or, by the other words, by the human factor. Nevertheless, Noyabrsk still demonstrates the largest urban greening trend (+ 0.6 %) when the trends in the natural vegetation cover have been subtracted. At the same time the NDVImax trend in Nadym is negative. The

[1] http://nadymregion.ru/news/11166-priglashaem-zhiteley-prinyat-uchastie-v-konkurse-nadym-cvetuschiy-gorod-kray-nego-severa.html

[2] http://neelov.ru/1830-v-nadyme-vysadili-ekzoticheskie-dlya-yamala-sorta-derevev.html http://newurengoy.rusplt.ru/index/Uchenye_pytajutsja_zasadit_Novyj_Urengoj_derev-jami-9412.html

reduction of productivity has been associated with the larch forest on the eastern rim of the city. It has been established that *Larix sibirica* forest negatively responses to the raising LST and air temperatures. The greening of the larch forest around Nadym is associated with the coldest spots of the LST map. Figure 3 shows that when the year of extremely high NDVImax (2014) is included in the analysis, the trends become positive in Nadym as well. Development of urban green spaces in Nadym consistently demonstrated implementation of the migrant's TEK. The city not only conserves the existing relict forest patches, such as dark-needle *Pinus sibirica* forest in the city park, but also actively introduces exotic southern plant species. It is interesting, that the ecological behavior is not considered as efforts to conserve patches of the natural vegetation types but as introduction of even larger areas of temperate vegetation[3]. The ultimate expression of such cultural attitude is given by the municipal program "Nadym – the blossoming city of the North" fostering the participation of city dwellers in the tree and flower planting work. Increasing psychological comfort might explain such a cherished attitude to the flowers and temperate trees (e.g. *Malus sylvestris*) in contrast to the widely presented neglecting of the natural vegetation systems.

There are two popular strategies in the NWS to reclaim the disturbed natural vegetation cover. The conservation strategy emphasizes the minimum human interference with the natural processes, whereas the tending strategy focuses on green development and urban afforestation. As applied to the NWS cities, both strategies seem to be rather idealized social constructs with little reference to the real physical environment of the territory. Many studies [e.g. Moskalenko, 2009; Koronatova and Milyaeva, 2011] demonstrated that the disturbed landscapes are reclaimed by essentially different vegetation communities. This study suggests that such a shift to alternative ecosystems is driven by the warmer LST among other factors which are more difficult to quantify.

CONCLUSION

In summary, this study shows that, at present, the physical climate change due to the surface urban heat island effect and the culturally motivated landscape modifications are broadly aligned. The NWS cities are associated with the warmer LST and embrace the more productive vegetation. The reviewed literature indicates that the urban vegetation communities are increasingly composed of more southern plant species. The specific efforts in the urban afforestation are directed towards planting temperate broad-leaf blossoming trees and tall shrubs. The warmer urban LST and creation of "urbanizems" [Srodnykh, 2008] support these efforts, and vice versa, the urban afforestation taken at large could maintain the urban heat islands. The SUHI may have also an unexpected implication for the climate change analysis in the region as the majority of meteorological stations are located within the SUHI (primarily at the airports).

ACKNOWLEDGEMENTS

This study was supported by the Belmont Forum and the Norwegian Research Council grant HIARC: Anthropogenic Heat Islands in the Arctic: Windows to the Future of the Regional Climates, Ecosystems, and Societies (no. 247268) and by the Centre for Climate Dynamics grant BASIC: Boundary Layers in the Arctic Atmosphere, Seas and Ice Dynamics.

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[3] A good illustration of this controversial perception of the conservation issues is given by a new 'Ecopark" project, see http://www.gazprom.ru/about/subsidiaries/news/2013/july/article166464/

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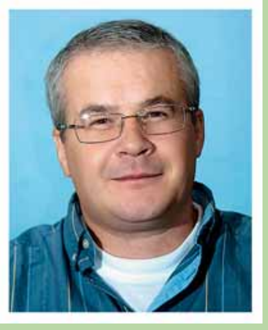
Received 29.07.2016 **Accepted 08.11.2016**



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DOI: 10.15356/2071-9388_04v09_2016_05

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MEDICAL AND DEMOGRAPHIC CONSEQUENCES OF CLIMATE CHANGE AND THE ASSESSMENT OF COMFORT LEVEL OF WEATHER-CLIMATIC CONDITIONS IN THE VOLGA FEDERAL DISTRICT

ABSTRACT. The paper provides a brief analysis of research on the impact of global climate change on human health. Using Tatarstan as an example, the paper discusses medical and demographic consequences of the extreme heat wave of the summer of 2010. Assessment of the Volga Federal District (VFD) bioclimate conducted with the help of certain biometeorological parameters allowed evaluating modern global and regional changes of weather-climatic conditions. The main emphasis was placed on spatial and temporal analysis of both the integral pathogenicity index (*I*) and its individual components for the district territory. In VFD, aggravating weather conditions increase from southwest to northeast. Summer months are associated with comfort weather conditions. In winter, the air temperature pathogenicity index and interdiurnal temperature fluctuations contribute the greatest to *I*; in summer, the role of cloudiness and humidity pathogenicity indices increases. The contribution of wind speed and interdiurnal pressure fluctuations to *I* is insignificant in all seasons. Analysis of the frequency distribution of *I* showed that comfort weather conditions (over 50 % of cases) occur in May–August, aggravating weather conditions occur in March-Appril, and harsh weather conditions in more than 50 % of cases occur in January–February and November–December. Calculation of biometeorological indices allows forecasting risk of thermal hazard under extreme meteorological conditions.

KEY WORDS: climate change, population mortality, biometeorological indices, bioclimatic comfort level.

INTRODUCTION

A characteristic feature of our time is the widespread awareness of the importance of global environmental change. Currently, climate change factors are considered along with other known risk factors for human health – environmental pollution, food insecurity, deterioration of the quality of drinking water, etc. [WHO, 2003; Sovremennyye..., 2006; Global..., 2007; Revich, 2007; IPCC 2013].

The recent decades have been the warmest recorded on our planet. The increase in global temperature of the Earth and the Northern and Southern Hemispheres, compared to the 1891–1900 level, has reached 1.08, 1.30, and 0.87 °C, respectively, in 2015, for the first time surpassing the "1 °C" mark [Byulleten…, 2015; Perevedentsev et al., 2015].

One of the direct consequences of global warming is the increase in the number of days with abnormally high temperature. Exposure to elevated temperature affects adversely primarily the more sensitive population groups, i.e., the elderly, children, and patients with high blood pressure and chronic respiratory disease or heart disease, causing heat stroke and meteotropic body reaction (exacerbation of chronic disease).

Modern research shows that weather (especially high air temperature) affects the mortality much stronger than previously thought. In years with an abnormally high air temperature mortality increases significantly in all age groups, especially among the elderly suffering from chronic diseases of the cardiovascular and/or respiratory systems [WHO, 2003; Malkhazova, 2006; Chazov, Boitsov, 2012].

Analysis of morbidity and mortality in 1961–1990 suggests that 166,000 deaths worldwide are associated with warming. According to the World Health Organization (WHO), climate change currently accounts for about 0.3 % of all deaths and 55×10^6 person-years of disability per year (0.4 % of global disability) [Revich, Maleev, 2011].

The extreme temperature rise in urban areas is especially dangerous. There has been even described the effect of "heat islands" located usually in urban centers with tall office buildings and paved area and a small share of open land, green spaces, and water surfaces. Thus, heat becomes a risk factor not only for the most vulnerable groups (elderly, young children, low-income people), but also for the employees of numerous government agencies, banks, and other offices located in city centers [Revich, Maleev, 2011]. As a rule, increased mortality in summer is observed in cities no later than the day after the extremely high temperatures. The use of air conditioners does not reduce mortality; during heat waves, it continues to be high.

The Roshydromet assessment report [Vtoroi otsenochnyi…, 2014] examined the effects of recent climate change (warming) in the territory of Russia. It drew attention to the increase in the recurrence rate (frequency) and magnitude of heat waves – long periods (within season) with extremely high temperatures. It has been demonstrated that continuous hot weather causes an increase in the number of deaths and diseases of the circulatory system (heart attack), cerebrovascular disease (stroke), respiratory diseases, diseases of endocrine system (diabetes), etc. [Haynes et al., 2004.; Revich et al., 2012]. The duration of heat waves affects the population greater in general than the value of maximum temperature, although for the elderly, the temperature factor is very important.

There were several recorded heat waves (e.g., in Moscow in 2001 and 2003) and the disastrous heat wave of summer 2010 in the European part of Russia due to a blocking anticyclone lasting for 55 days, from June through mid-August. It resulted in a dry and very hot weather. Throughout the entire July, air temperature rose above 30 °C, reaching 39.6 °C in Kazan, which is the upper limit of air temperature oscillation for this location. The heat wave dramatically weakened only with the passage of the cyclone from west at the end of the second decade of August [Analiz usloviy..., 2011]. The heat wave that continued through the first half of August resulted in the most significant increase in mortality, more than 1.5 times compared to August 2009, in a number of regions and republics of the European part of Russia. The main cause of increased mortality of the population was circulatory system diseases (34,000 out of 54,000 total cases). This is supported by the data on the mortality structure during heat waves. [Revich, Maleev, 2011; Vtoroi otsenochnyi…, 2014].

High temperatures in summer months have been observed in recent years in many cities in Europe and the US, which led to a significant number of additional deaths. For example, in Chicago in 1995, the heat wave has caused more than 500 cases of heat-related deaths [Witman et al., 1997]. Furthermore, in August 2003 in Western Europe, the heat wave resulted in more than 70,000 additional deaths [Fouillet et al., 2008].

It has been suggested that global warming could double the number of very hot days in the temperate zones. Global warming will greatly increase the frequency of heat waves [IPPC..., 2013]. For example, in the UK, the summer of 1976 was extremely hot. It was an extremely rare event then, but in the current half-century (up to 2050) such an event will take place every 5–6 years [McMichael et al., 2002].

According to climate models forecast scenarios, warming will continue in the XXI century (Kislov et al., 2008; Ekologo-geograficheskiye…, 2011). The effects of climate warming on the population may be different in the northern and southern regions, as southerners are better adapted to the heat. The greatest impact can be expected in areas where high temperatures are not recorded regularly.

According to the US Environmental Protection Agency [Global..., 2007], the temperature threshold at which mortality begins increasing significantly varies for different US regions. Such spatial-temporal assessments may be also valuable for Russia and other countries of the temperate zone.

Calculations [Strategichesky prognoz…, 2005] suggest that increase in the number of days with high temperatures in the summer period can occur practically in the entire territory of the Russian Federation. It means that almost in all settlements of Russia, except in the south, even a brief heat wave, i.e., temperatures above 29 °C, can lead to an increase in the number of hospitalizations and deaths.

We have undertaken a comprehensive study, including assessment of the Volga Federal District (VFD) bioclimate, its impact on human health, identification of potential areas of climatic resources of the territory, and the assessment of the comfort level of the environment under modern global and regional climate change [IPCC, 2013; Vtoroi otsenochnyi …, 2014; Perevedentsev, 2014, 2015].

MEDICAL AND DEMOGRAPHIC CONSEQUENCES OF CLIMATE CHANGE IN THE TERRITORY OF TATARSTAN

Analysis of medical records for 8 years (2008–2015) in the territory of Tatarstan showed that during the extreme heat of the summer 2010 (July–August), there was a sharp increase in the number of deaths, i.e., 2,528 more deaths compared to July–August of 2009. The effects of the heat in August 2010 were more devastating than in July 2010 (Table 1, Figure 1).

Thus, there was a 52.4 % increase in mortality in August 2010 compared to August 2009; the

Table 1. The rate of summer mortality in the Republic of Tatarstan in 2008–2015 (number of deaths per 100,000 population)

Month	Year							
	2008	2009	2010	2011	2012	2013	2014	2015
June	115.6	110.6	109.9	103.3	99.3	99.3	95.8	110.7
July	111.9	102.6	119.6	112.1	103.6	102.9	101.9	96.0
August	101.7	94.9	144.6	102.8	98.3	95.5	97.0	92.6

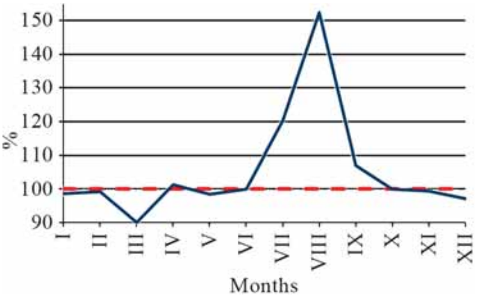

Fig. 1. Monthly mortality rate of the Tatarstan population in 2010 (solid line) and in 2009 (dashed line).

extreme heat of summer of 2010 had a direct negative effect on the Tatarstan population. There was another heat wave in the VFD in July-August 2016 as a result of a continuous blocking anticyclone.

BIOCLIMATIC ASSESSMENT METHODS AND THE COMFORT LEVEL OF THE TERRITORY

One of the most important meteorological factors that cause morbid meteotropic reactions are interdiurnal changes in temperature, pressure, humidity, wind speed, oxygen density, etc. [Isaev, 2001]. Assessment of the human body response to external stimuli is based on medical statistics on ambulance calls, morbidity, and mortality; assessment of the comfort level of weather conditions is conducted based on various biometeorological indices [Revich, Maleev, 2011; Revich, Shaposhnikov, 2012; Shartova et al., 2014].

Currently, there are a significant number of approaches and methods of evaluation of the environmental comfort level [Tkachuk, 2012], which is basically is the assessment of the bioclimatic comfort level, i.e., calculation of bioclimatic indices characterizing features of the thermal structure of the environment and determining, first of all, human thermal perception [Hentschel, 1988; Isaev 2001, Evelina et al., 2014].

Expert assessments [Rukovodstvo..., 2008, Vinogradov, 2012; Vtoroi otsenochnyi …, 2014; Emelina et al., 2014] suggest that the most universal and available for different regions of the country primary meteorological characteristics required for assessment, which most reliably represent the bioclimatic comfort level of the territory, are the parameters used in this work and listed below.

Effective temperature (ET) – characterizes heat or cold perception by the human body, which is determined by A. Missenard's method. The most comprehensive is the algorithm modified by R. Steadman [Steadman, 1994].

Equivalent-effective temperature (EET) – a combination of meteorological parameters, which produces the same thermal effect as still air at 100 % relative humidity and a certain temperature; determined by A. Missenard's method adjusted by B. Eizenstat [Eizenstat, 1964]. Frequency of *EET* in the interval 17–22 °C characterizes potential climatic resources of the territory.

Weather severity index (S) (humidity cooling as per Hill and wind chill as per Bodman) – characterizes the severity of weather and potential duration of a person's presence and activity outdoors.

Description of these parameters, their estimation algorithms, and interpretation of the obtained results are provided in works on the bioclimatic comfort level [Zolotokrylin et al., 1992; Vinogradov, 2012; Gamburtsev, Sigachyov 2012; Vtoroi otsenochnyi…, 2014; Emelina et al., 2014.; Emelina et al., 2015.; Shartova et al., 2015].

The ***integral meteorological pathogenicity index I*** proposed by V. Boksha and B. Bogutsky [Boksha, Bogutsky, 1980] was calculated to evaluate short-term effects of weather conditions on human health:

$$I = I_t + I_f + I_v + I_n + I_{\Delta p} + I_{\Delta t},$$

where I_t – temperature pathogenicity index: $I_t = 0.02 *(18 - t)^2$ at a temperature of less than or equal to 18 °C; $I_t = 0.02\ (t - 18)$ for

t > 18 °C; t – daily average temperature, $I_{\Delta t}$ – interdiurnal temperature pathogenicity index Δt; I_f – humidity pathogenicity index; f – daily average relative humidity (%); I_V – wind pathogenicity index; V – daily average wind speed (m/s); I_n – cloudiness pathogenicity index, which is determined on a 11-point scale; n – point cloud; $I_{\Delta p}$ – pathogenicity index of the interdiurnal atmospheric pressure change Δp.

In practice, the following working formula is used to calculate I (in points):

$$I = 10\frac{f-70}{20} + 0{,}2V^2 + 0{,}06n^2 +$$

$$+ 0{,}06(\Delta p)^2 + 0{,}3(\Delta t)^2 + I_t.$$

The authors of the method [Boksha, Bogutsky, 1980] suggested three grades of the meteorological pathogenicity index (Table 2).

Table 2. Grades of the meteorological pathogenicity index

Pathogenicity index	0–9	10–24	24
Weather conditions	Optimal (comfort)	Excitant	Acute

Bioclimatic assessments are based on methods for measuring impacts of different weather systems on human health, primarily, interdiurnal fluctuations of meteorological parameters [Isaev, 2001; Rukovodstvo…, 2008; Vinogradov, 2012]. The absolute values of interdiurnal changes in air temperature Δt (C°), atmospheric pressure P (hPa), and the value of the partial density of oxygen (ρ_{O_2}) were estimated based on the All-Russian Research Institute of Hydrometeorological Information data for the VFD 19 weather stations for 1966–2010. The evaluation of I and its individual components was carried out for 12 months using current meteorological observations for 1966–2013. First, the formula's components were calculated based on the daily average data and then their multi-annual average values were calculated for each of the VFD 19 weather stations, which allowed performing assessment of the annual pattern and territorial differences in I. The section below presents the results of the calculations of some bioclimatic parameters listed above.

RESULTS AND DISCUSSION

The distribution of the estimated bioclimatic parameters in the VFD territory allowed us to evaluate the quality of the human living environment in the modern period.

Statistical analysis of the interdiurnal fluctuations of meteorological parameters showed that in January, most interdiurnal ***air temperature*** fluctuations Δt (°C) are within the range of 0–4.0 °C (60 %); in July in about 60 % of cases, these differences occur in the range of 0–2.0 °C. A similar situation is characteristic of ***atmospheric pressure*** Δp (hPa). Thus, in January in 60 % of cases, it does not exceed 6 hPa; in July, fluctuations of Δp in 61 % of cases occur in the range of 0–2.7 hPa. Thus, the bulk of the interdiurnal fluctuations of meteorological parameters have a relatively small numerical value and only in 29 % of cases in January Δp exceeds 8 hPa, and Δt in 14 % of cases exceeds 8 °C, which has an adverse effect on humans [Isaev, 2001]. In summer, these parameters are considerably milder and large fluctuations are rarely observed.

Calculation of the partial oxygen density (ρ_{O_2}) showed that in winter, the air is saturated with oxygen to a greater extent than in summer. There is a pronounced seasonal variation. The ρ_{O_2} values averaged over the VFD 19 stations vary from 283.1 g/m^3 (July) to 324.4 g/m^3 (January). The annual average ρ_{O_2} value is 303.7 g/m^3. In January, it increases from 321 g/m^3 to 328 g/m^3 from southwest to northeast. In July, the contour lines of the ρ_{O_2} values assume the zonal pattern and the oxygen content in the air is increasing northward from 280 g/m^3 to 285 g/m^3. In other months, there is also a northward increase in this parameter, which means that it is easier to breathe in the northern part than in the southern part of the region, where air masses are less oxygenated.

The distribution of the ***effective temperature in the territory of the region*** (Fig. 2) shows

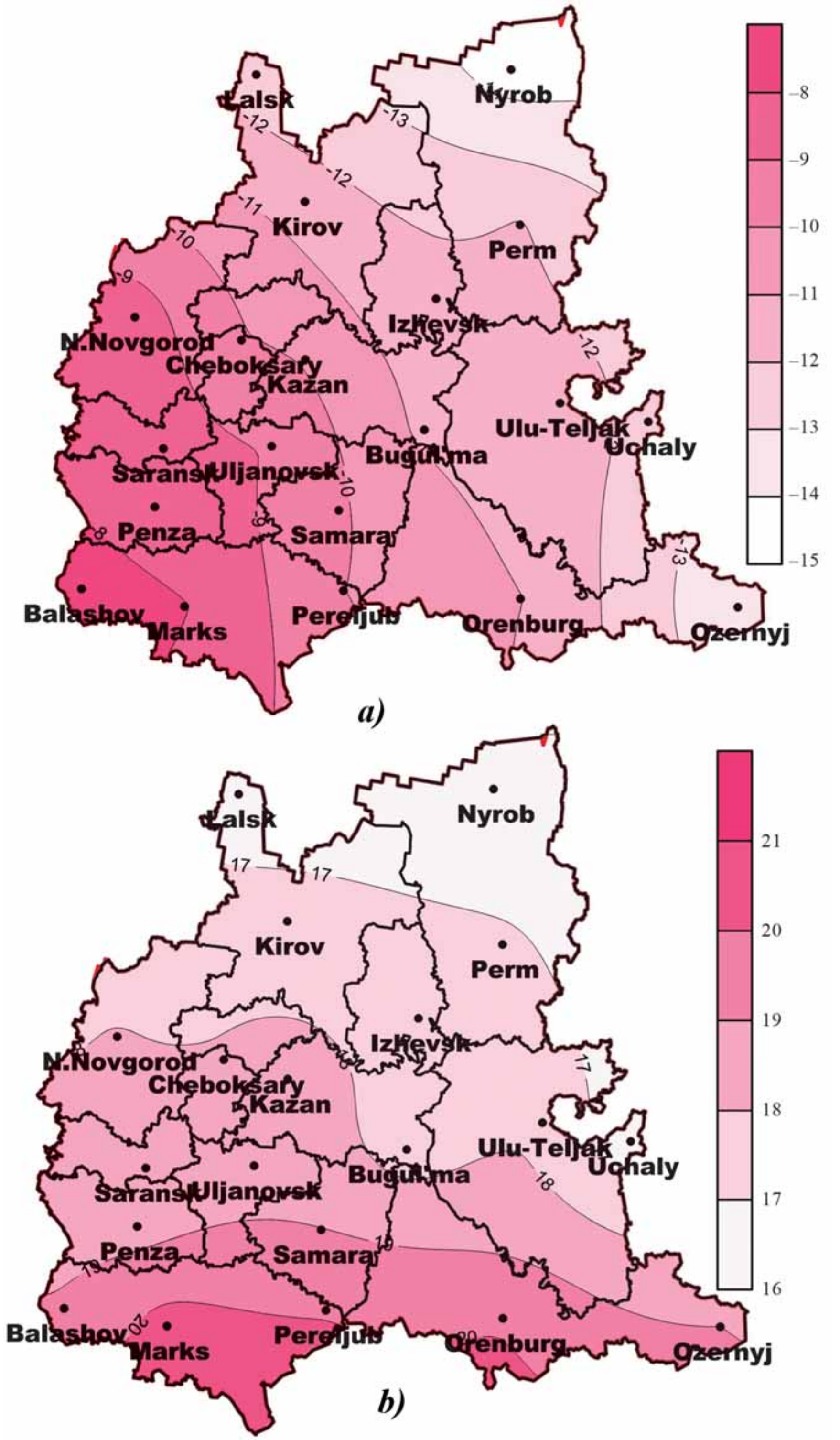

Fig. 2. Effective temperature *(ET),* °C: a) January; b) July

significant differences both in the territory and the seasons of the year. *ET* averaged over the VFD territory varies within the year from –10.7 °C (January) to 18.1 °C (July) (annual average value is 4.0 °C). The lowest *ET* values are observed in the northeastern part (Nyrob), where in January, *ET* = –14.5 °C and in July, *ET* = 16.1 °C (annual average value is 1.0 °C). In the far southwestern part of the region (Marks, near Saratov), the *ET* values are the highest (in January, *ET* = –8.0 °C and in July, *ET* = 20.4 °C (annual average value is 6.5 °C).

The Steadman's effective temperature averaged over the region varies throughout the year from –5.0 °C (January) to 24 °C (July). The probability of exceeding the minimum threshold of thermal safety (ET_S < 18°C) is highest in July; frequency (%) of values $ET_S \leqslant$ 18°C is 63.0, 25.1, 9.3, 25.7, and 73.9 % in May, June, July, August, and September, respectively. From this perspective, the likelihood of comfortable weather (reduced risk of thermal hazard) is higher in May and September than in summer months. In the territory, this index increases markedly from south to north. Thus, in July, it increases from 3 % in the southern part of the region to 24 % in the northeast.

Frequency of values was calculated for the following ranges: < 18 °C – minimal risk; 18–22 °C – average risk; 23–28 °C – high risk; and >28 °C – extreme risk. The results averaged over the VFD are presented in Table 3.

The minimal risk of thermal hazard is observed in May and September; the thermal hazard risk increases significantly during summer months, especially in July, within the ranges 23–28 °C and > 28 °C. The risk of thermal hazard significantly diminishes from south to north.

Frequency of the number of days with values of Eizenstat equivalent-effective temperature in the 17.3–21.7 °C range (comfortable weather) is the highest in July (23.0 %). Monthly distribution of the probability of occurrence of comfortable weather is as follows: 6.2 % (May), 16.0 % (June), 23.0 % (July), 14.0 % (August), and 2.4 % (September). Probability of comfortable weather is the greatest in the southern part of the VFD and the lowest in the northern part (Fig. 3). Calculation of the *EET* linear trend slope coefficients shows a weak increase in the number of days with a comfortable weather.

Calculation of *the* ***Bodman weather severity index*** during the cold period shows that mild winters are the most common condition for the VFD territory. The most likely situation is when winter is either moderately or mildly harsh (Table 4). The highest values of the Bodman index are observed in January and its maximum values are characteristic of the northeastern part of the territory.

Evaluation of ***the integral I index and its components*** for the VFD shows that the territory exhibits a well-defined annual pattern with the maximum in November-February, which characterizes weather conditions as harsh (*I* is greater than 24 across-the-board); in March, April, September, and October, aggravating weather conditions are formed at most stations (*I* varies from 10 to 24); and only

Table 3. Average frequency (%) of different ET_S ranges in summer period

Range of ET_S, °C	Month				
	V	V	V	V	V
<18	63.0	63.0	63.0	63.0	63.0
18–22	22.8	22.8	22.8	22.8	22.8
23–28	16.4	16.4	16.4	16.4	16.4
>28	1.0	1.0	1.0	1.0	1.0

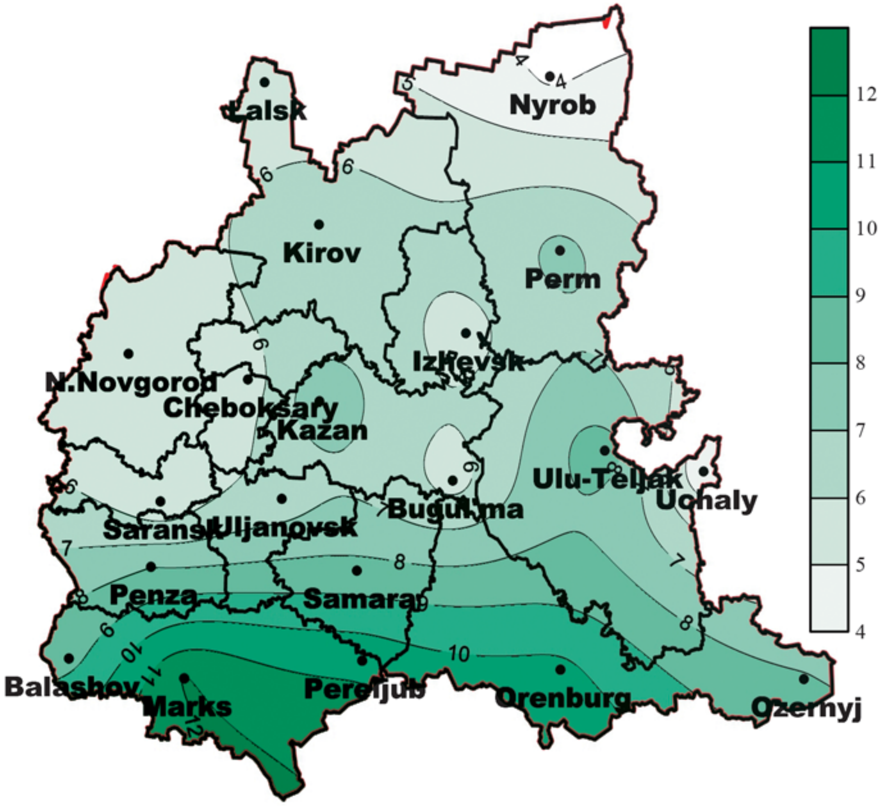

Fig. 3. Distribution of the multi-annual average number of days with comfortable *EET* in July

in summer months, weather is comfortable at most stations, with the exception of the northern part (Lalsk, Nyrob). Of course, this is only the average climate pattern, which sometimes can vary greatly. Notable territorial differences in the distribution of *I* in the district should also be noted: for the most part of the year, there are aggravating and harsh weather conditions in the northern and northeastern parts of the VFD (Lalsk, Nyrob); in the southwestern part of the district (Balashov), comfortable weather is present from May through September. The acute weather is usually formed in the cold time of the year under active synoptic conditions with rapid movement of air masses and weather fronts,

Table 4. Frequency (%) of the Bodman index averaged over the VFD territory, by ranges

Scale of weather "severity"	Month				
	XI	XII	I	II	III
B < 1	0.8	0.0	0.0	0.0	0.8
1 < B < 2	62.5	36.7	26.8	29.8	60.6
2 < B < 3	33.2	50.6	54.6	54.6	33.6
3 < B < 4	3.1	11.0	15.4	13.0	4.5
4 < B < 5	0.3	1.4	2.6	2.3	0.5
5 < B < 6	0.1	0.2	0.5	0.3	0.1

resulting in significant short-term changes of meteorological parameters, low temperature background, and high relative humidity.

Analysis of *the* ***component indices of pathogenicity*** (components of the formula) by months was conducted using data from three stations located in different geographical conditions: Nyrob (northeast), Kazan (center), and Balashov (southwest). In winter, the air temperature pathogenicity indices I_t (temperature deviation from the optimum) and $I_{\Delta t}$, due to large interdiurnal fluctuations in temperatures, provide contribute most to I; in Balashov, the most important factor is the humidity pathogenicity index I_f. During summer months in Kazan and Balashov, comfortable weather conditions are prevalent and the influence of the individual indices is insignificant. Among them, the role of the cloudiness and humidity pathogenicity indices is important, while that of wind speed and the contribution of interdiurnal pressure fluctuations is small. In the extreme northeastern part of the district (Nyrob), where natural conditions are most severe, even in July, the overall index is 10.6 and the largest contribution to pathogenicity comes from humidity, cloudiness, and interdiurnal temperature fluctuations.

Frequency of occurrence of weather conditions by the ranges of *the pathogenicity index* (0–9, 10–24, and > 24) is presented in Table 5 which shows the data averaged for the VFD based on the calculations performed for all stations.

Comfortable weather conditions prevail in May–August (frequency is greater than 50 %); aggravating weather conditions prevail in March–April and October, and harsh weather conditions prevail in January-February and November–December. Comfortable weather conditions are characteristic of the southern part of the VFD; the index (0–9) decreases from 70 % to 50 % from south to north.

Thus, assessment of medical and demographic impacts of climate change and the comfort

Table 5. Frequency of the pathogenicity index

Months	Ranges of/values		
	0–9	9.1–24	> 24
I	0.0	9.3	90.7
II	0.0	16.1	83.9
III	3.7	53.8	42.6
IV	32.5	53.6	13.9
V	52.1	41.6	6.3
VI	62.3	34.5	3.2
VII	67.0	30.9	2.1
VIII	57.8	38.2	4.0
IX	39.4	49.7	10.9
X	16.4	55.4	28.2
XI	1.1	32.1	66.8
XII	0.1	12.4	87.5

level of weather and climatic conditions in the VFD territory has shown that:

– due to the summer heat wave in 2010 in the territory of Tatarstan, there has been a sharp increase in the number of deaths (over 50 %);

– the most adverse climatic conditions are formed in the northeastern part of the VFD; during the year, the integral pathogenicity index varies from 35.5–50.3 (January) to 14.3 to 5.7 (July); the largest contribution to the integral index are made by the components that depend on the temperature deviation from the optimal, interdiurnal temperature fluctuations, humidity, and cloudiness.

– comfortable weather conditions, on average for the VFD, are prevalent in May–August (more than 50 % of cases), while aggravating conditions are characteristic of October and March–April, and harsh conditions occur in November and February.

CONCLUSION

According to forecasts, climate change in the XXI century will have an impact on humans, mostly aggravating existing health problems. The Climate Doctrine of the Russian Federation [Klimaticheskaya…, 2009] considers a range of issues associated with adaptation of the population and economy to the occurring and future climate change in the interest of sustainable development of the country. The relevance of the problem is substantiated by the fact that the Strategy for activities in the field of hydrometeorology for the period up to 2030 (2010) emphasizes the need to develop forecasts that include assessment of the influence of various meteorological parameters on specific diseases, taking into account aspects of climate change. Early adoption of measures would allow the country to minimize the risk of thermal hazard and decrease the number of additional deaths and exacerbation of chronic diseases. The results presented in the paper indicate that it is necessary to consider the risks to human health, especially in extreme weather conditions. The authors are continuing research in this area by using other biometeorological indices to assess the comfort level of weather and climatic conditions in the VFD territory for the population living in the present and in the future under global and regional climate change.

ACKNOWLEDGMENTS

This work was supported in part by grants RFBR (№ 15-05-06349) and RGS-RFBR (№ 15/2015/RGS-RFBR, 01/04/2016).

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Received 24.10.2016 **Accepted 08.11.2016**

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DOI: 10.15356/2071-9388_04v09_2016_06

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TRANSFORMATION OF ENVIRONMENTAL PROBLEMS IN MOSCOW: SOCIOLOGICAL DIMENSION

ABSTRACT. The paper assesses transformation of environmental situation in Moscow and citizens' attitude toward those changes. It analyzes a mass poll of 800 Moscovites conducted in June–July 2015. The research was aimed at identifying the correlation between subjective perception of residents and objective spatial and environmental differentiation in Moscow as well as assessing the potential of Moscovites' involvement in solution of environmental problems. Air pollution caused by production enterprises and cars, solid household waste and waste incineration plants were given special consideration. The article analyzes how Moscovites perceive problems of the whole city and of their own districts.

KEY WORDS: environmental sociology, environmental situation in Moscow, state of environment, public opinion, spatial differentiation, modernization of public environmental consciousness.

INTRODUCTION

With 12197 thousand residents, Moscow is the largest Russian city [Demographic Yearbook of Russia, 2015]. After city borders were moved in 2012, its area became 2511 sq.km (the research reviews the area of old Moscow, which accounts for approximately one-third of that value). Moscow is administratively divided into 12 districts which include 125 municipalities.

Among all Russian cities, Moscow is the 7th based on the integral index of human impact, the 2nd based on emissions, the 1st based on water consumption and waste waters, and the 16th based on reduced volume of waste given their toxicity [Bityukova, 2015]. The air is polluted, average annual concentration of nitrogen dioxide (NO_2), nitrogen oxide (NO) and formaldehyde (CH_2O) are above allowed sanitary standards and growing in 2010–2014 [Yearbook…, 2015]. In other words, objective deterioration of the environment on specific indicators or its aggregated value exceeds self-purification capacity of natural constituents. According to sociologists, there is also a subjective criterion of unfavorable environmental situation (ES), when a person (segment, group, territorial community, etc.) considers it to be a real threat to his/her interests and quality of life [Sosunova, 2005].

In terms of municipal administration and self-administration, subjective assessment of environmental situation in a city often turns out to be more important than objective assessment. Public opinion, environmental maturity of public consciousness, and preference of active or passive environment protection measures may create an information field and intensify nature conservation activities in districts or in the city. The way residents perceive the state of the environment (SE) in different districts influences their perception of the quality of urban environment as well as development of housing market in the city.

First sociological research on how Russians perceive SE was carried out in Moscow in the 1990s. Moscovites noted environmental problems, on the one hand, objectively due to an always complex environmental situation (large scale, rapid development of transport, and inherited industrial facilities ensured Moscow's top place in a country-wide ranking), and, on the other hand, subjectively due to a high level of education.

1993–1999 saw the number of Moscovites, who were primarily concerned with «the dirt and environmental situation», decreased from 26 to 17 %, but environmental problems remained at the 3rd place after elevating crime level and high cost of living up until 1997 when a greater number of Moscovites mentioned non-payment of salary [Yakovlev, 1999]. Citizens invariably consider air pollution to be the main environmental problem and cars to be the main polluter, while paying almost no attention to noise pollution. However, as for industrial areas, 50 % of respondents mentioned closing them as a high-priority measure; however, as for cars, 47 % proposed new environmentally safe public transport and new roads and thought that the least benefits could be achieved through underground crosswalks and increased taxes on old cars as those problems were not widely discussed by mass media. «Lack of administrative attention toward environmental problems» was the second among reasons for unfavorable SE in 1993 and the seventh, the last, in 1999 [Fomichev, 1999].

The poll of 2015 when respondents could choose top three problems revealed that 67.5 % of Moscovites blame transport, 51.2 % – environmental situation and 51.1 % – healthcare. 62 % of respondents consider ES in Moscow to be rather unfavorable or nearly catastrophic. According to them, main polluters are cars (59 %), industrial and energy facilities (27 %), now they also include household waste and waste incineration plants (17 %).

Main purpose of the research is to define correlation between subjective perception of environmental situation and actual spatial differentiation in Moscow in 2015, factors influencing SE in various districts, and Moscovites' attitude toward environmental changes after the collapse of the USSR.

OVERVIEW OF STUDIES

Publications pursue one of three directions. Research based on anthropological approaches and aimed at studying attitudes toward the environment, in particular, waste and garbage, in different communities. "Rubbish Theory: The Creation and Destruction of Value" by M. Thompson, focused on conceptual study of waste, was one of the earliest works in this group [Thompson, 1979]. A monograph by M. Douglas, first published in 1966 and classics already, studies various pollution concepts and taboos in different communities [Douglas, 2001]. The majority of publications are dedicated to specific environmental and waste issues in cities [Melosi, 2005] and attitudes toward pollution in public discussions [Bickerstaff, 2003].

The second direction represents a systemic approach to study correlation between society and environment, functioning of ecosystems, and applied dimensions of solutions for sustainable development of ecosystems [McGinnes, Ostrom, Ostrom, 2009, Plieninger, etc.].

The third direction may be referred to as critical sociology or radical approach in studying society and environment. Those publications study and criticize consumer society that damages the environment. J. Bennet's publication on philosophical issues in political ecology was among the first ones in this group [Bennet, 2010].

O.N. Yanitsky, A.S. Ahiezer, A.V. Baranov, L.B. Kogan are eminent Russian scholars who have laid foundations for a discipline that later became known as environmental sociology [Ahiezer., 1969, Baranov, 1984, Kogan, 1967, Kogan, Listengurt, 1975, Yanitsky, 1998]. In the 1990s, there have been a number of research projects in Moscow related to Moscovites' attitude toward environmental situation in the city and changes in pollution [Bityukova V., Sokolova, 2008, Fomichev, 1999, Yakovlev, 1999].

DATA AND METHODS

There were two stages of research: objective assessment and community study.

Transformations in spatial structure of industrial pollution were assessed based on integral indices of human impact for industrial areas (IA) in Moscow, including amount of emissions (according to statistical accounting of industrial emissions), emission density, pollution areas, and structural complexity of emitted aerosol and its toxicity.

Intensity and structure of traffic in Moscow were measured and subsequently used in order to analyze pollution from cars. Impact areas of streets were calculated based on OND-86 method [Tischenko, 1991]; amount and density of pollution in the areas – based on running exhaust emission.

A mass poll was conducted in June-July, 2015 in order to understand how Moscovites perceive environmental problems. Six municipal districts of Moscow have been selected for polling: Novokosino, Perovo, Sokolinaya Gora, Mozhaisky, Krylatskoye, and Novo-Peredelkino. The selection was based on the following: it had to include districts with different levels of environmental pollution, districts located in semi-peripheral and peripheral parts of the city, approximately equally remote from the center. Within the districts, respondents were selected based on quota sampling consistent with sex-age structure of each district.

Central districts were excluded from the research as there are totally different reasons for choosing the city center as a place of residence (prestige, high quality of housing, including new housing). Residents do not take environmental situation into account.

Therefore, resulting sample structure is similar to sex-age structure (SES) of district population. Overall, there were 800 respondents, from 103 in Novokosino to 170 in Perovo. The questionnaire consisted of the following parts: assessment of changes in the environmental situation in Moscow and in the district; ranking of polluters in the city and in the district; questions about environmental behavior of Moscovites and others.

RESULTS AND DISCUSSION

Changes in environmental situation in Moscow and in the districts.

More than half of respondents (53.5 %) believe that environmental situation has deteriorated over the past five years. Another 26 % think that it has not changed. Most likely they are more interested in municipal improvement than in environmental problems. Respondents mention the following specific manifestations of deteriorating environment: air pollution (84 %), deterioration of health and parks (38 %), dirty ponds (32.5 %), and disappearing green belts (32.5 %); only 1 % mention increasing noise pollution (Fig. 1).

However, there is no objective proof: industrial and car emissions have not grown in Moscow, average annual concentrations have decreased or remained stable, within allowances: CO – 0.2 daily average threshold limit value (TLV); particulate matter pollution that was 10 microns in diameter or less (PM10) – 0.9; NO average annual TLV – 0.7; NO_2 – 1.3.

Assessment of changes in industrial pollution.

Two main trends are currently typical of environmental situation in Moscow: *deindustrialization and decreasing industrial pollution and growing car pollution*. Air pollution from stationary sources has declined

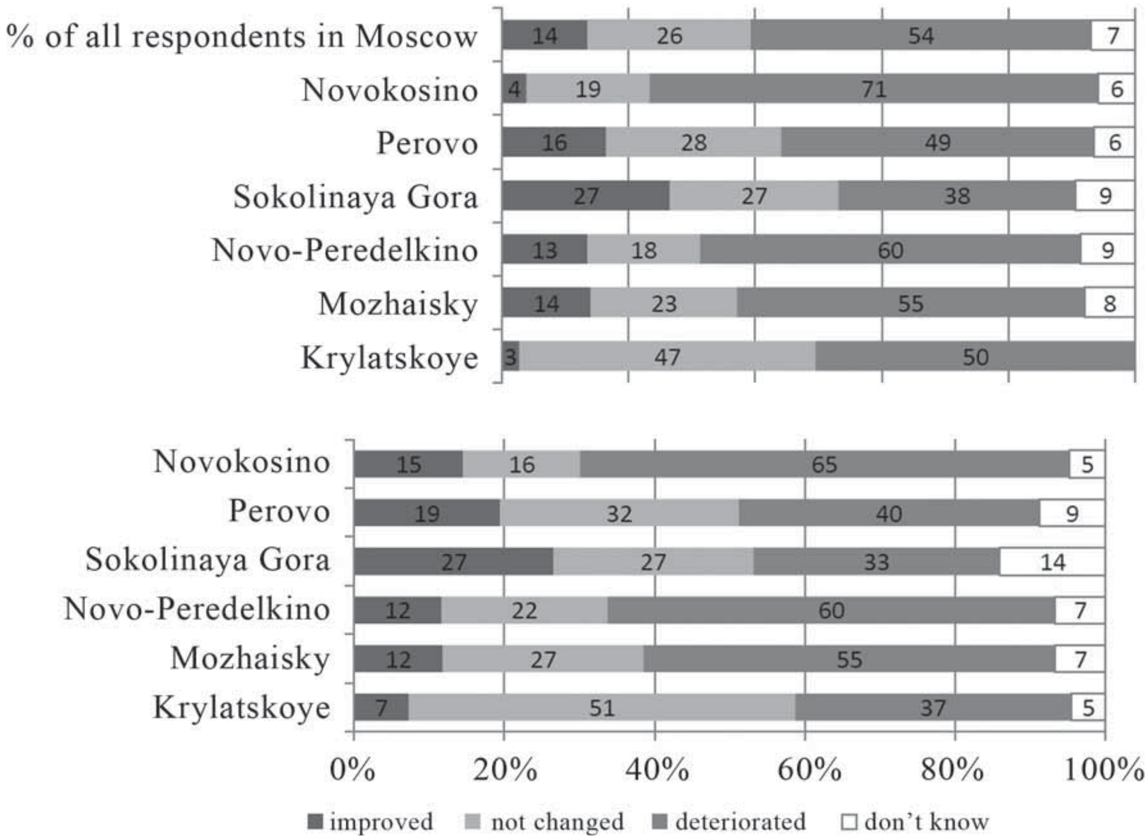

Fig. 1. Distribution of answers to the question: Has environmental situation changed in Moscow (upper) and in your district (lower) in the past five years? (Per cent of respondents from the district)

from 26–27 % in the early 1990s to 10 % by 2000 and to 6 % by 2014. Industrial pollution has undergone the maximum reduction. In the early 1990s, Moscow was the 15th–16th top polluted Russian city based on the total pollution from stationary sources, which could be compared to Nizhny Tagil, Angarsk and Krasnoyarsk and exceeded pollution in Ufa, Yaroslavl, and Chelyabinsk. In 2001 Moscow moved to the 20th place and until now is only in the top thirty.

Moscow, similarly to the majority of large cities, has an even reduction in pollution from stationary sources after 1990. Overall production in 1999 accounted for 40 % of the 1990 level, which ensured an adequate emission reduction of 38.6 % (from 367 to 141.3 thousand tons/year (1998)). Later Moscow saw mostly chaotic closure of production enterprises. However, the default resulted in compensating rise of industry: overall production grew by 2.5 % in 1998, 8.9 % in 1999, 7 % in 2001. At the same time, unlike the majority of Russia's cities where production growth was accompanied by increasing emissions, total pollution from stationary sources in Moscow was still declining – up to 105 thousand tons and 50 thousand tons in 2001 and 2009, respectively, – as the result of changes in industry structure in general and of specific enterprises due to environmental policy and reconstruction. But the growth after the 2008–2009 crisis still caused increase in emissions by 71–68 thousand tons in 2012–2014 (Fig. 2).

Stationary sources and their emissions are distributed unevenly. As main industrial polluters are oil refinery in Kapotnya and combined heat and powers facilities (CHPs) the majority of analyzed districts have a manifold smaller share of stationary sources. Only in Perovo and Sokolinaya Gora it is 1.5 times greater than the average Moscow value. While the overall emissions from stationary sources tended to decline in 2008–2014 (average annual reduction of 15 %), Krylatskoye, Novo-Peredelkino, and Novokosino saw pollution decreased by 90 %, Mozhaisky and Perovo – by 55 %, and Sokolinaya Gora – only by 10 %. Emissions decreased both in industry and in housing and utilities due to equipment modernization of boilers or transition to gas fuel.

Industrial areas experienced an uneven reduction of emissions in 1992–2014. Emissions considerably decreased by the early 2000s, mainly at the expense of well-developed industrial areas in the middle belt of Moscow which specialized in mechanic engineering and heavy industry. As the result,

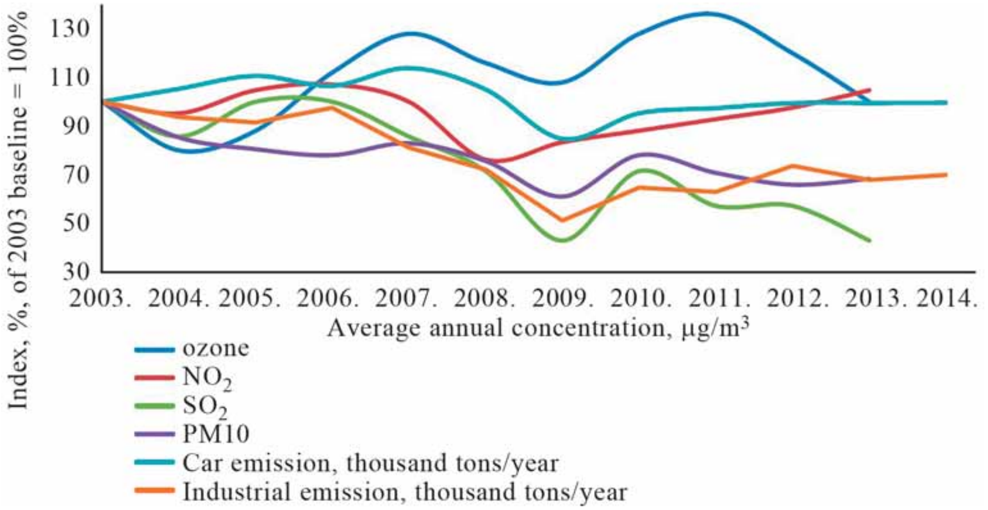

Fig. 2. Average annual concentrations of pollutants in Moscow

an age-long gap in Moscow's industry, with a traditionally more developed east, is gradually closing due to a more intense reduction in large enterprises. Krylatskoye, Mozhaisky, and Novo-Peredelkino do not include any industrial areas (IA); separate polluters are located along the periphery. Mozhaisky district shares a southern border with Ochakovo IA, with a CHP at the core, which partially affects the district, and a northern border with Kuntsevo IA, specializing in mechanic engineering (Elektroschit, JSC), that has no significant impact (Table 1).

Perovo municipal district is the most environmentally unfavorable district in the Eastern Administrative District. However, Perovo IA sees a rapid replacement of industrial functions with housing and public ones. The impact has most significantly decreased after Kuskovo chemical plant, JSC was closed and an apartment complex was built in its place. Sokolinaya Gora municipal district has experienced minimum reduction, as Sokolinaya Gora IA in the south has a strong impact. Woodwork is on the rise there, the emitted aerosol has a more complex structure now, though its density and toxicity have slightly decreased. Small industrial areas, Semenovskaya and Kirpichnyeulitsy, have almost no impact, but still have not been reconstructed. Neighboring districts also have minimum impact: Khapilovskaya IA has no serious polluters; serious polluters in SerpiMolot IA have been eliminated. Energy facilities are down to a small Ufaev CHP-11 in Sokolinaya Gora IA, emitting less than 800 tons.

Environmental situation in Novokosino changed in 2003, when Moscow Waste Incineration Plant 4 was built in Rudnevo IA. Saltykovsky forest separates it from residential areas; there are six cleaning steps of exhaust gas and a thermal station using alternative fuel – solid household waste. And still it affects Novokosino – residents complain about it. According to the number of complaints, Kosino-Uhtomskoye and Novokosino are the most unfavorable Moscow districts [Report…, 2014].

Industry remains a crucial factor of toxicity due to specific emissions. Production enterprises were combined into special areas for two main reasons: to minimize chemical, noise, and other impact on residential areas and to boost efficiency due to large production complexes on limited territories. But gradually houses approached industrial areas despite urban development standards. Thus, in terms of urban development programs it is important to assess whether residents understand that industrial areas are a hazard.

Table 1.

Municipal district	Industrial areas in the district (main enterprise)	1992	2002	2014
Krylatskoye	No			
Mozhaisky	*Kuntsevo* (All-Russian Institute of Light Alloys JSC)	Strong	Moderate	
Novo-Peredelkino	No			
Perovo	*Projector* (Moscow Electrode Plant)	Strong	Moderate	
	Sokolinaya Gora (Nefteprodukt Moscow Plant (Rosneft), Ufaev CHP-11)	Strong		
Sokolinaya Gora	*Semenovskaya* (SalutGaz-Turbine Engineering Research and Production Center)	Moderate	Insignificant	
	Kirpichnye ulitsy (AREMZ-1 First Automotive Equipment Maintenance Plant, JSC)	Moderate	No impact	
	Sokolinaya Gora (*Vperyod* Moscow Automotive Equipment Maintenance Plant)	Strong		
Novokosino	No	No impact		

Residents'assessment of industrial pollution

The results of the poll were rather unexpected. Eighty two and a half percent of respondents in Novokosino consider industry to be the main environmental problem in Moscow (as compared to the average Russian value of 40 % [Abramov, 2014]), almost 40 % believe that waste incineration plant is the key environmental threat in the district. Residents of Mozhaisky and Sokolinaya Gora placed industry on the 2nd place and residents of Krylatskoye, Novoperedelkino and Perovo – on the 3rd. Only 35 % of residents in Perovo and 40 % in Sokolinaya Gora mentioned industry as the main polluter in their districts.

Therefore, in general, residents understand the role of industry and its impact on environmental situation in Moscow (slightly more) and in their districts. However, when it comes to purchasing residential property, Moscovites stop seeing the problem both for objective and subjective reasons [Popov and others, 2016]. Their subjective attitude toward environmental situation depends less on lack of information and environmental illiteracy in the housing market and more on difficulties in interpreting ecological information for an ordinary person, and impossibility to assess the potential threat.

Assessment of changes in car pollution

Car pollution has grown only by 14 % since 1990 (932.2 thousand tons in 2014), despite a sevenfold increase in the number of cars. The early 1990s saw the maximum annual increase in the number of cars (19.1 %), later the situation stabilized, and 1996 saw a radical change – the growth of the number of cars started to decline. Recently the growth of the number of cars has slowed down to average annual 5 % (2.7 % in 2013), which clearly demonstrates that the market is saturated.

Growing number of cars is accompanied by active fleet renovation with cars of a higher environmental class (approximately by 2–3 % a year); decreasing number of trucks (nearly twice during 1991–2006) improves environmental situation. According to the experts, data on vehicle age show that in the past decade, the share of cars of environmental class above 4 (Euro-4) has grown from 0 to 50 %, for trucks – to 30 %, and for buses – to 16 % by early 2014.

Fuels below Euro-4 class (running exhaust emission (g/km) is twice lower than for Euro-3 and thrice lower than for Euro-2) have been prohibited in Moscow since 2013, fuels below Euro-5 –since January 2016. Replacement of fuel class 3 with fuel class 4 resulted in SO_2 emissions decreased by 79 %, benzpyrene by 22.7 %, solid emissions by 13.5 %, NO and CO_2 – each by 4 %. Fifty percent of motor fuels used in Moscow corresponded to class 5 already in 2014. [Report…, 2015].

Though the target has been achieved, there almost no reserves left to reduce emissions by improving the quality of motor fuels. Better gasoline and new structure of vehicle fleet, first of all in large cities, helped decrease total and specific car pollution. Running exhaust emissions have decreased by four times. Those changes have annihilated the dependency of emissions on the number of cars. Since 2007 the rapidly growing number of cars in Moscow has not led to more emissions.

Remarkably, the past fifteen years have seen a more equally distributed car pollution that is moving from working to residential areas. Implementation of construction projects and road reconstruction decrease the number of areas with maximum pollution (Table 2).

Areas with the average emission density of 1000–2000 tons/sq.km/year were relatively stable during 2002–2014. Other groups saw a significant redistribution. About half of the areas remained unchanged in the groups of 3000–5000, 500–1000, and 100–500. At that, the majority of areas, formerly belonging to the group of 500–1000, experienced an increase in polluters' density. The opposite is true for the group of 3000–5000. Car emission density has averaged, i.e., human impact is

Table 2. Groups of areas based on emission density, share of the total area of Moscow

Emission density (tons/sq.km/year)	1992		2002		2014	
	Number of areas	Share of total area of Moscow, %	Number of areas	Share of total area of Moscow, %	Number of areas	Share of total area of Moscow, %
Less than 500	27	17	37	26 (+9 %)	35	34 (+8 %)
500–1000	27	19	43	23 (+4 %)	39	32 (+ 9 %)
1000–3000	71	38	70	43 (+5 %)	94	28 (–15 %)
3000–5000	42	22	20	5 (–17 %)	18	5
More than 5000	11	4	8	3 (–1 %)	4	1 (–2 %)

now distributed more evenly. This could have been a positive trend, but growing pollution in peripheral areas compensated for declining peaks (primarily, at the intersection of radial motorways and the Garden Ring). Moreover, the number of areas with low density has decreased as well.

Therefore, selected districts have car emissions proportional to the population size but for Mozhaisky district (Western Administrative District) where the share of emissions is larger due to Kutuzovsky Avenue that is daily used by up to 250 thousand cars.

Model districts have different structure of car pollution in the affected areas along main motorways (Fig. 3):

– Perovo and Sokolinaya Gora have the majority of car emission areas with the density of 1000–1300 tons/sq.km, with certain areas near industrial zones of 3000–3500, and certain areas of up to 4000 tons/sq.km. Novokosino is dominated by areas with the density of 1000–1300 tons/sq.km, but has no local highly dense areas.

– Krylatskoye and Mozhaisky have the majority of car emissions areas with the density of 1500–2000 tons/sq.km along the streets. Novo-Peredelkino has the same density along the roads, but has less internal pollution areas of 500–1000 tons/sq.km.

Therefore, cars are a background factor of the quality of the environment; its pollution and noise are rather homogeneously distributed across the city.

Cars are the main polluter in all districts: 90 % of overall emissions in Perovo and Sokolinaya Gora and 98 % in other districts. From Moscovites' perception, the role of cars is less significant. In terms of their districts, the majority of respondents consider cars to be the main reason for environmental degradation: from 48 % in Perovo and Sokolinaya Gora to 78 % in Krylatskoye. But in terms of Moscow, 20–30 % plus, on average, consider cars to be the main polluter.

What is more important, despite the fact that it was the transition to Euro-5 fuel that ensured better quality of the air, Moscovites have little understanding of its environmental advantages. In 2014, only 18 % of the respondents said that they had heard of Euro-5 environmental standard and 44 % knew nothing about planned ban on fuels below Euro-5. Only 40 % agreed that Moscow oil refinery exclusive production of Euro-5 fuel since 2013 ensured less air pollution in Moscow and only 26 % suggest prohibiting sale of fuel below this standard. At that no more than 66 % feel positive effect of the implementation of this standard, and 21 % are for closing Moscow roads for old cars. This attitude is likely to reflect growing fuel prices.

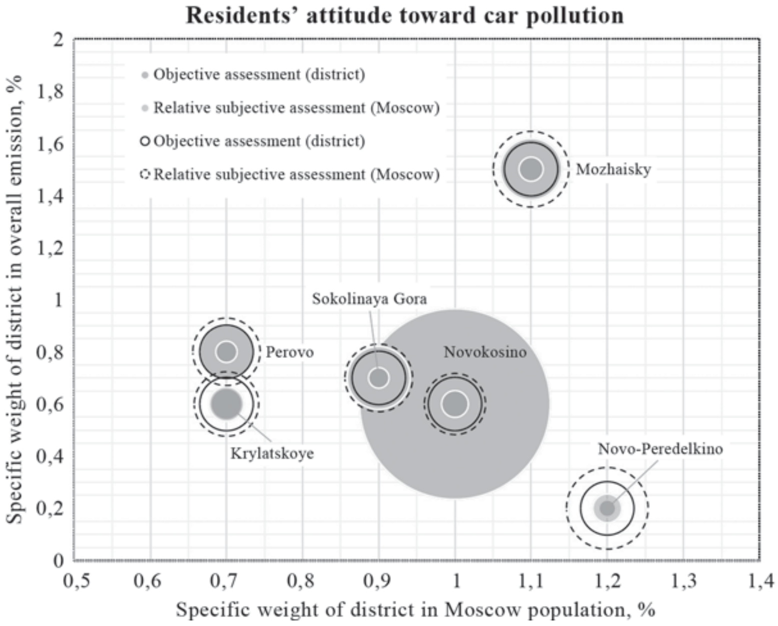

Fig. 3. Correlation between the share of respondents, who call cars the main polluter, and the level of auto air pollution.

Moscovites are hardly ready for steps to reduce car load: only 47.8 % believe that it is very important to use public transport and environmentally safe transports (bicycle, electric cars) and 34 % believe that it is rather important; only 23 % are ready to act.

Residents'assessment of solid household waste

Moscow annually produces more than 3 million tons of solid household waste. Only recent years have seen a reduction from 3.2 in 2012 to 2.5 million tons in 2014. Household waste and dumping sites are a pressing problem for modern cities, yet it has not cemented in citizens'consciousness.

The poll respondents have placed household waste and dumping sites on the 3rd place both for their districts and for Moscow. The number of respondents who call solid household waste the leading problem for the city is approximately three times higher than for their districts: 62 % in Krylatskoye, 59 % in Perovo, 54 % in Novo-Peredelkino, and 47 % in Mozhaisky.

Ten to seventeen percent consider household waste to be the main polluter in their own districts. Not only Moscovites underrate the size of the problem, try to move it away, and do not see the consequences, but they are against waste incineration plants. The residents of Novokosino, where the waste incineration plant is located, are most responsive to this problem (74 % of respondents in the district). The district regularly witnesses protests against this enterprise. The residents also mention the impact of Kuchinsky solid waste landfill that deteriorates underground and open waters.

Involvement in solution of environmental problems

Moscow undergoes a more rapid social and demographic modernization than other Russian regions, including greater environmental responsibility of residents. Some questions were aimed at defining specific features of modernization of public environmental consciousness of Moscovites. Key features of modernization of environmental consciousness

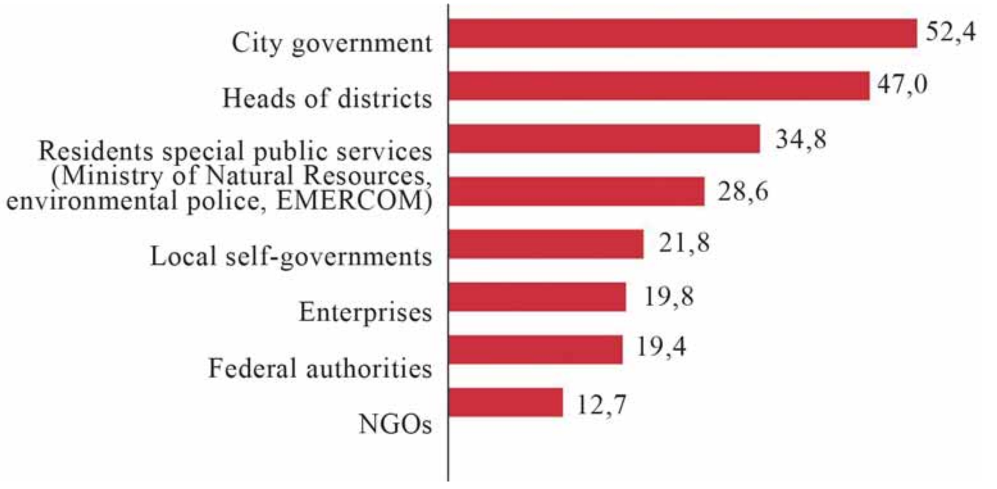

Fig. 4. Answers to the question: Who do you think should be responsible for environmental situation in your district? % of respondents, N = 800

and readiness for environmentally responsible behavior are: vigorous interest in solving environmental problems, involvement in environment protection measures, awareness of the environmental situation and main polluters and pollution indicators, and personal responsibility for the environment.

The analysis of this part of the questionnaire should take into account the large number of university-educated respondents that influences the number of respondents interested in environment protection.

The majority of respondents rest responsibility upon municipal authorities. However, a good sign is that 34.8 % believe that residents themselves are responsible for the environment. They could form a proactive group of citizens concerned with the environment (Fig. 4).

CONCLUSIONS

Comparative analysis of ES indicators and sociological research revealed that the main objective factors for difference between the actual situation and the residents' attitude are as follows:

– Environmental situation improves or remains stable while residents, on the contrary, pay more attention to it as the result of less social tension. During the transition period, this factor had much less impact due to existential threats that caused declining interest toward environmental values.

– Recent years have seen leveling of urban pollution as the result of breakthroughs in the industry and transport. The west-east differentiation has become less obvious. This confirms that environmental requirements are, to a great extent, programmed, i.e., people either got used to (or accepted) conditions they live in, or took them into account when moving to a given district.

– Environmental situation in Moscow is characterized by a substantially decreasing role of factors that could be influenced by large investment aimed at technological production modernization, i.e., an increasing role of waste that Moscovites do not consider to be an obvious environmental factor; this problem demands involvement of citizens. However, according to the research, citizens do not perceive it locally.

Subjective factors include:

- lack of knowledge and environmental illiteracy, difficulties in interpreting ecological information for an ordinary person, and impossibility to assess potential threat of polluters;

- absence of accurate and objective criteria of environmental conditions that results in divergence of visually-based perception of environmental situation in separate districts from actual situation.

- latent nature of environmental factors in residents' consciousness and, as the result, underestimation of environmental threats and consequences of current actions. Social studies call this phenomenon the shift of future plans in human preferences. Sometimes, human behavior is irrational; the results we choose now do not always match the outcomes we want later [Medvedev, Aladsheva, 2001].

- despite the dominant role of car pollution among environmental problems, ease of travel largely compensates for the harm in residents'opinion.

- assessments of environmental situation in the districts are usually based on comparisons. That is why transit districts are underrated. Life of the majority of residents is limited to the center and the middle belt; residents of remote districts see a broader picture, as they daily travel across all the belts. That is why dynamics of assessments requires special attention.

Public opinion, environmental maturity of public consciousness, and preference of active or passive environment protection measures may create an information field and intensify nature conservation activities in the districts or in the city. The majority of environment protection measures are not initiated by residents but are organized by the government. Until now, despite a more dynamic interaction between the population and authorities in management, cultural, and even urban development spheres, potential of environmental consciousness as an important resource for territorial development and better urban environment remains unclaimed and is not used by municipal administration or environmental NGOs.

ACKNOWLEDGEMENTS

The research was conducted with support from the Russian Geographical Society: Integral environmental evaluation of the Russian cities and regions grant – public response 07/2014–П1.

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Received 26.03.2016 **Accepted 08.11.2016**

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DOI: 10.15356/2071-9388_04v09_2016_07

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INTENDED NATIONALLY DETERMINED CONTRIBUTIONS FROM THE MIDDLE EAST AND NORTH AFRICA

ABSTRACT. All Parties to the United Nations Framework Convention on Climate Change (UNFCCC) were requested to communicate intended nationally determined contributions (INDCs) in a clear, transparent and understandable way before the Conference of the Parties (known as COP21) held in Paris in 2015. The Contributions were supposed to be balanced and comprehensive to ensure sustainable development and expected to include finance, technology requires, technology transfer and capacity building aiming at mitigation and adaptation. This research focuses on investigating the INDCs prepared by countries from the Middle East and North Africa (MENA), one of the most water-scarce and dry regions in the world. Following a content analysis, this research has found that INDCs from the region have not been able to reflect the desired output. Submissions were also not timely and not sufficiently ahead of time. Many countries were not able to disclose the current status. INDCs can play a significant role by providing objective, timely, and reliable information, which is missing at present in the countries from MENA.

KEY WORDS: INDC, MENA, Climate change, UNFCCC.

INTRODUCTION

While bringing couple of thousands of delegates from across the globe, 'environmental mega conferences' [Seyfang, 2003] have been stipulating and instigating ideas as well as concrete plans and programs to address climate change both locally and globally.Through consensus the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) formulate strategies required to bring down global emission and thereby lessen the pace of global warming. Preparation of national adaptation programmes of action (NAPAs) and nationally appropriate mitigation actions (NAMAs)are such initiatives formulated during the Conference of the Parties (COP) in Marrakesh (i.e. COP7) and Doha (i.e. COP18), respectively. Later, during COP19 in Warsaw, based on the negotiations under the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP), Parties to the Convention were invited to prepare and submit intended nationally determined contributions (INDCs) in an attempt to *intensify domestic preparations*.

All Parties were requested to communicate INDCs in a clear, transparent and understandable way before COP21held in Paris in the winter of 2015. More specifically, Parties were invited to submit INDC by the first quarter of 2015. However, only four countries – Switzerland, Latvia, Norway and the USA, out of 158 submissions before January 2016, were able to submit by the designated time. Thirty-five countries communicated their INDCs during the month of November and December of 2015 only. UNFCCC has developed a publicly available platform to store and disseminate INDCs.

The Contributions were supposed to be balanced and comprehensive to ensure sustainable development and were expected to include finance, technology requires, technology transfer and capacity building aiming at mitigation and adaptation actions. Developing countries should have prepared different sets of INDCs mentioning the level of financial requirement and technology involvement. To address mitigation both in long term and short term, INDC has to summarize the national mitigation contributions, its type, level of ambition and the relevant conditionality, if requires. Country has to outline current and future adaptation actions and the supports needed to implement adaptation and climate resilient development. NAMAs, NAPAs, the national adaptation plans (NAPs) and the previous national communications, if any, to the UNFCCC were suggested to be considered as the key data sources.

Forthe implementation plans of INDCs financial supports, provisions for capacity building and technology transfer need to be explained. Current and anticipated national spending on mitigation and adaptation, supports require for policies, sector strategies and projects as well as the needs of various types of environmentally sustainable technologies are expected to be elucidated in INDCs. For each activity, the time of support required, national budget available, if any, and the essential external funding have to be mentioned. As the country-level capacity varies, it is not realistic to expect that all Parties would be able to explicitly explain the actions, needs and the future plans. Hence, this research investigates INDCs prepared by the countries from the Middle East and North Africa (MENA) complying with the UNFCCC requirement. Even late, compared to many other countries, Morocco was the first among the MENA region to submit the document in June 2015 followed by Tunisia, Israel, Lebanon and Jordan in September 2015. Among the Gulf Cooperation Council (GCC) countries, Oman was the first to submit INDC in October 2015. Other nations from the region have submitted till December 2015.

The MENA region is one of the most water-scarce and dry regions in the world and particularly vulnerable to significant warming, longer and intense droughts and uncertain rainfall [Sowers and Weinthal, 2010; Benzie et al., 2012; World Bank, n.d.]. Countries in the region are expected to be impacted differently by diverse climate risks [Sowers and Weinthal, 2010]; for instance, sea-level rise would affect parts of Egypt, Tunisia and small Gulf States while change in precipitation may affect surface water flow in Turkey, Jordan and Morocco. Along with other reasons, due to its climate-sensitive agriculture and large share of inhabitants in the flood-prone urban coastal zones, the MENA region has developed indigenous technologies and institutional mechanisms to adapt with heat and water scarcity [World Bank, n.d.].

Climate Action Tracker (CAT), a coalition of four research organizations – Climate Analytics, Ecofys, New Climate Institute and Potsdam Institute for Climate Impact Research, has assessed 32 INDCs about emissions, effect of current policies on emissions and fair share of global effort to limit warming below two degree Centigrade. Among these only three are from MENA – Morocco, Saudi Arabia and the UAE. CAT has ranked INDCs of both Saudi Arabia and the UAE 'inadequate' while Morocco has been rated as 'sufficient. 'However, this research is planned to analyze the contents of selected INDCs entirely from a qualitative point of view without making any ranking.

SELECTION OF COUNTRIES AND THE TEXT OF INDCS

This research has applied content analysis method. In this pursuit, it has collected 16 INDCs from the countries in MENA except Djibouti, Syria, and West Bank and Gaza, which did not submit their respective INDCs until the point of data collection. Among these 16 available INDCs, Iraq and Kuwait have submitted their reports in Arabic language, thus reducing the choice to 14 INDCs to compare on various aspects of national intended contributions towards climate change. In the first phase, the study has analyzed the content of the reports and grouped the countries into several categories (shown in Table 1). Owning to the subjective nature of reports, there is a chance of arbitrary grouping. To avoid this happening, experts' opinion has been sought for in case of any confusion arisen in grouping the words. Finally, this research has come up with eight separate classes of words. It is seen from Table 1 that in general, MENA countries are much concerned about the emitting sectors (the sources of emission for instance, transport, factory emission, heat and wind). The second most important factor that has attracted attention from these countries is how to adopt (for instance, rehabilitation, resilience and capacity building) with the damage that have already caused to the environment. The least priority area as shown by the list is the pollutants (the nature of polluters like waste and thermal pollutants). Also, financing requirement is not emphasized much which is a good indication that the region can cope by their own financial capacity with the environmental adversaries.

The descriptive statistics of word counts are provided in Table 2. It shows the average as well as minimum and maximum of each cluster of words. It can be observed that the source of emission has received extensive coverage from Jordan followed by Tunisia and Yemen. These three countries are also the most agile among the sample countries in terms of reporting environmental concern. In contrast, Oman is the most conservative in expressing their status about environment followed by Israel.

Table 1. Country wise word count

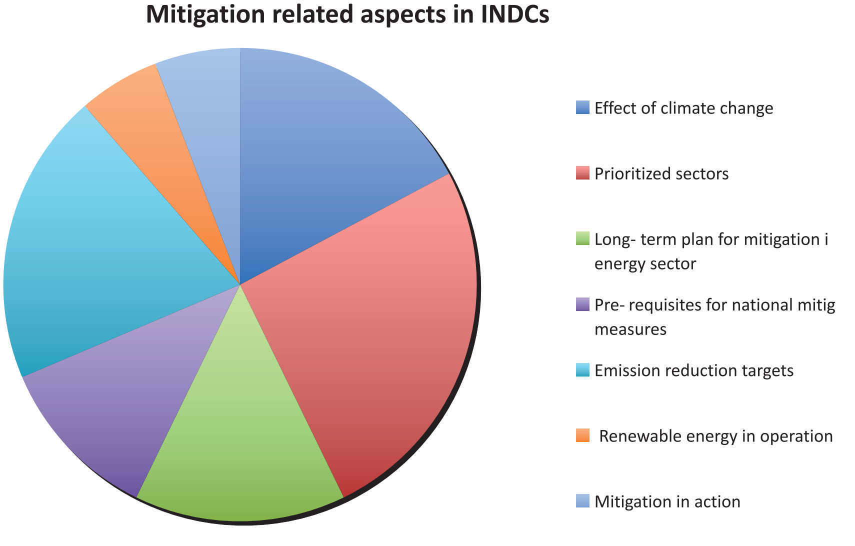
	Adaptation	Mitigation	Financing	Vulnerability	Pollutants	Emitters	Consequences	Preparation
Algeria	51	60	11	9	19	50	5	9
Bahrain	45	16	6	10	4	60	17	24
Egypt	76	58	25	18	14	91	30	29
Iran	53	79	23	13	7	43	12	6
Israel	11	12	5	1	5	46	8	10
Jordan	168	101	68	62	18	327	134	138
KSA	52	38	14	18	6	43	13	20
Lebanon	78	98	7	14	3	49	41	10
Morocco	55	81	35	24	14	66	35	32
Oman	24	14	4	1	3	16	3	8
Qatar	30	43	9	9	10	51	23	10
Tunisia	91	154	53	17	34	217	27	33
UAE	33	28	20	9	8	61	26	17
Yemen	165	72	32	42	9	112	50	45
Sum	932	854	312	247	154	1232	425	391

Table 2. Descriptive statistics

	Adaptation	Mitigation	Financing	Vulnerability	Pollutants	Emitters	Consequences	Preparation
Mean	66.57	61.00	22.29	17.64	11.00	88.00	30.29	27.93
Median	52.50	59.00	17.00	13.50	8.50	55.50	24.50	18.50
Stan Dev.	47.55	40.24	19.23	16.35	8.45	83.98	32.88	33.80
Minimum	11	12	4	1	3	16	3	6
Maximum	168	154	68	62	34	327	134	138
Sum	932	854	312	247	154	1232	424	391
N	14	14	14	14	14	14	14	14

MOST DISCUSSED ISSUES IN INDCS

Majority of the countries have discussed about the effects of climate change more detailed than the existing measures addressing mitigation in practice. In addition to the discussions about prerequisites for mitigation plans, many countries have elaborated mitigation plans in energy sector, emission reduction targets and potentials as well as prioritized sectors. With regard to adaptation, priorities, current interventions, strategies and challenges have well been discussed by the selected countries. Few countries, namely Iran, Qatar and the UAE, have ensured intensive discussion on water sector, one of the priorities of the MENA nations. Figure 1



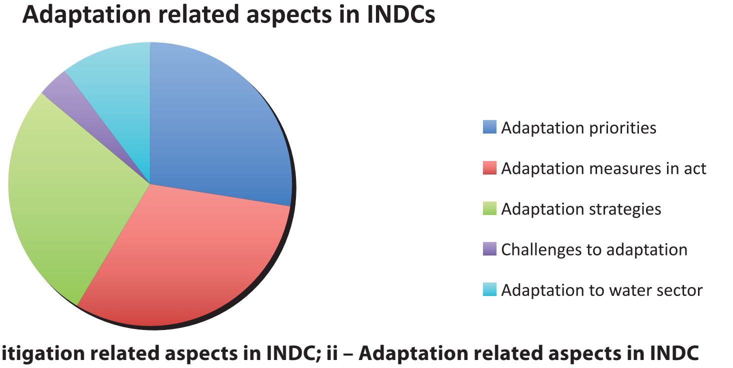


Fig. 1. i – Mitigation related aspects in INDC; ii – Adaptation related aspects in INDC

(both i and ii) has summarized the major issues related to mitigation and adaptation discussed in INDCs of the countries from MENA.

MITIGATION MEASURES IN ACTION

Quantitative analysis of emissions and national mitigation contribution backed by adequate data are hardly found in INDCs from the countries in MENA except the case of Morocco. Various types of contributions towards mitigation as well as both long- and short-term ambitions are not quantified. While addressing mitigation strategies, Tunisia has identified the challenges to energy sector. Bahrain, due to its smaller size in terms of population and economy, has explicitly mentioned deficiency in financial and technical capacities along with unavailability of emission-reduction technologies. Iran has mentioned that available hydrocarbon resources are the reasons to rely on energy-intensive industries that have made upward trend of greenhouse gas emissions in the country.

Algeria has been maintaining bottom-up and top-down methodological approach for mitigation concerning sectors and national objectives, respectively. However, other countries have hardly discussed about methodological approaches for emission reduction. Few countries have discussed about energy and electricity, energy demand, distribution and risk, renewable energy potential and importance of renewable energy technologies; however, challenges to reduce emission from energy sector have not been detailed by most of the countries in MENA.

ADAPTATION MEASURES IN ACTION

Although priorities and strategies are mentioned frequently in INDCs, detailed discussions about critical aspects of adaptation are not well penned. The expected contents about current and future adaptation actions, necessary supports for adaptation and climate resilient development are hardly found in the selected INDCs. Water sector has been the focus for few countries; besides, adaptation measures in natural resources, coastal zone management and agriculture have received minimal attention. Egypt and Yemen have discussed a little about the challenges for intervening adaptations. Among the GCC countries, Oman and Saudi Arabia have discussed more about the challenges to adaptation. Compared to the GCC countries, African nations have deliberated their strategies to adaptation more structurally.

FINANCIAL REQUIREMENT

In an attempt to showing financial requirement for addressing existing and planned adaptation and mitigation measures, most of the countries from MENA have not been efficacious enough. Few countries have emphasized on the necessity for financial resources, Tunisia for instance. Tunisia has also specifically given an estimation of financial requirement for capacity building. The only exception in the region is Saudi Arabia; it has not asked for any financial support from the external parties. The reportof the country states *"the implementation of Saudi Arabia's INDC is not contingent on receiving international financial support, but the Kingdom of Saudi Arabia sees an important role for technology cooperation and transfer as well as capacity building for INDC implementation."* Other countries from the region have asked for financial support in addition to national planned spending or national dedicated allocation for climate change action, for instance Jordan. Unlike the demand of Saudi Arabia, other oil exporting countries have asked for external financial support to implement INDCs.

TECHNOLOGY REQUIREMENT

Technologies already in use and technologies required for implementation of planned projects were expected to be well documented in INDCs; however, few countries from the MENA region have been able to incorporate the issues. Iran, Oman, Saudi Arabia and Tunisia have mentioned some technologies, but have not discussed in detail about the specific technologies they need. While describing technologies, countries have mentioned, for instance about smart technology for agriculture, eco-friendly technology, technology for irrigation and water savings as well as technologies for renewable energy. Specification of environmentally sustainable technology, as asked by the UNFCCC for INDCs, has not been addressed. Egypt and Tunisia have discussed about the funding requirement for technology transfer.

CAPACITY BUILDING

Although explanation about current and potential capacity to implement projects has been a goal to be explained in INDCs, many countries have not been able to sufficiently elaborate their cases. Government policies, national target for 2030 and existing national programs and plans have been illustrated by most of the nations. Examples of national initiatives already been undertaken showing the capacity of the respective country are explained by the countries except Saudi Arabia and Oman. Capacities of the countries ranges from vulnerability assessment to legal and institutional framework development to core implementation of projects like solid waste management, protection of archeological sites and initiation of public transport system. Table 3 shows the core capacity concerns and the respective application the countries claim.

CONCLUSION

This research has attempted to investigate the status of environmental facts and figures reflected in INDCs submitted by MENA nations before COP21. In so doing, the research has applied content analysis method. Since there is a dearth of this kind of research in the existing literature, the study provides new information about the status of environmental facts of the sample countries. The research also has some practical policy implications. Content analysis shows that the World Bank's expectation about MENA region's *repository of traditional and institutional knowledge* preservation and dissemination towards a global effort to address climate change [World Bank, n.d.] has not been sufficiently reflected in the submitted INDCs. Results of the analyses show that majority of the countries in MENA are not able to structurally formulate national communication, like INDCs. Jordan's INDC is more detailed compared to those submitted by other countries. Specially, non-GCC nations (among the MENA countries) seem to be more serious about the preparation of INDC compared to that of GCC countries. Effective policy making requires the flow of information in a timely fashion. If the concerned countries do not submit their INDCs well ahead of time, the preparatory committees will not have sufficient time to prepare the agenda that would reflect the real needs of the country to tackle environmental problems.

Some countries are not open enough (Oman and Israel, for instance) in disclosing their status of environment. Thus, timely submission of INDCs alone is not sufficient for strategizing climate policies; rather countries should bring reliable and measurable information sufficient enough for formulating action-oriented policies. In addition, information disclosed by most of the countries is very subjective in nature, which makes it difficult to understand and interpret. In this regard, a pro-forma specimen can be designed for uniformity and better analysis of data. The research also shows that some countries are not explicit about their current actions and future strategies in adaptation to and mitigation of climate change. Sustainable living in this planet requires an urgent and collective response to resolve the problem.

Table 3. Capacity concern of the MENA countries towards INDCs

Country	Most discussed issues on capacity development in INDCs	
	Core activities	Derived focus
Algeria	Government policy, 2030 target, national programs, plan for capacity development program	Institutional framework, solid waste management, land erosion and desertification
Bahrain	Government policy, 2030 target, national programs, prerequisite for national mitigation measures	Integration of mitigation and adaptation, thermal insulation on buildings, use of liquefied petroleum and natural gas
Egypt	Government policy, 2030 target, national programs, prerequisite for national mitigation measures	Vulnerability assessment of sectors, enforcement of environmental regulations, protection against touristic and archeological sites, regional water circulation
Iran	2030 target, national programs, technology requirement	Reduction of energy consumption, operational efficiency by reducing leakage of natural gas, electricity transmission and distribution
Israel	2030 target, conflicting interest with biodiversity and energy production	Institutional arrangement and policies
Jordan	2030 target, national program, planned activities	Substantial number of projects on mitigation
KSA	Investment in Research and Development	–
Lebanon	2030 target, government policy, plan for capacity development	National energy efficiency action plan
Morocco	2030 target, government policy, national programs	Legal and institutional reform aiming green economy
Oman	–	–
Qatar	Government policy, national programs, plans for capacity development	Waste treatment facilities, development of public transport systems, export of liquefied natural gas, investment in education and research for environment and climate change awareness
Tunisia	2030 target, government policy, national programs	Reduction of emission in different sectors
UAE	Government policy, plan for capacity development	Tariff reform, building construction and efficiency standards
Yemen	Target 2030, plan for capacity development, challenges to adaptation	Rural development, small holder agricultural productivity management, integrated coastal zone management

In this regards, INDCs can play a significant role by providing objective, timely, and reliable information, which is missing at present in many countries from MENA. Although many countries have addressed issues differently, overall the countries from MENA have shown inordinate similarities in communicating INDCs to the UNFCCC. ■

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Received 11.10.2016 **Accepted 08.11.2016**

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ISSN 2071-9388

SOCIALLY SCIENTIFIC MAGAZINE "GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY"

No. 04(v. 09) 2016

FOUNDERS OF THE MAGAZINE: Faculty of Geography, Lomonosov Moscow State University and Institute of Geography of the Russian Academy of Sciences

The magazine is published with financial support of the Russian Geographical Society.

The magazine is registered in Federal service on supervision of observance of the legislation in sphere of mass communications and protection of a cultural heritage. The certificate of registration: ПИ МФС77-29285, 2007, August 30.

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Sent into print 28.12.2016
Order N gi416

Format 70 × 100 cm/16
8.45 p. sh.
Digital print
Circulation 600 ex.