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WATER RESOURCES – AN ANALYSIS OF TRENDS, WEAK SIGLANS AND WILD CARDS WITH IMPLICATIONS FOR RUSSIA

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WATER RESOURCES – AN ANALYSIS OF TRENDS, WEAK SIGLANS AND WILD CARDS WITH IMPLICATIONS FOR RUSSIA[4]

Water resources are crucial for the continuity of life. Humans and living species need fresh water for drinking and sanitation, while most, if not all, industries need water for some part of production processes and products themselves. Access to fresh water is a grand challenge at the global level, mainly due to increasing water consumption, low rate of replenishment of resources as well as external factors, like climate change, that significantly reduce amount of water available. The solution to the existing water problems require a systemic approaches for sustainable use of water resources, while advancing water infrastructure and providing circular use of water.

Research presented in this paper, focuses on the use of water resources in Russia with a long term perspective developed through a Foresight study. Russia is one of the countries, which is relatively better positioned compared to a number of other countries in the world regarding the availability of water resources. However, there are still considerable issues regarding the protection and use of water resources, purification processes, water networks, consumption patterns, discharge, treatment and re-use. The present study aims to develop strategies and for the use of water resources with a long term time perspective. The first step involved a scanning exercise, to be followed by future scenarios and strategy proposals for action. Presenting the results of the scanning phase, the paper begins with the review of the key issues and challenges concerning water resources. Particular attention is paid to the state-of-the-art in the three domains identified in the scope of research: (i) sustainability of water systems, (ii) water use by households and industry, and (iii) new water products and services. Furthermore, trends, weak signals and wild cards identified in the course of the study, as well as their implications on water resources in Russia are discussed. The paper concludes with a brief description of the next phases of the study and follow-up activities planned in the project.

JEL: H4, H5, H87, I30, M11, R20, R52, Q01, Q02, Q15, Q18, Q22, Q25, Q26, Q27, Q53, Q54, Q55

Keywords: water resources, sustainable water systems, water use, water goods and services, trend scanning, weak signals, wild cards.

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Introduction

Access to clean water is a Grand Challenge. The intensity of this challenge varies between countries depending on their geographical location and level of socio-economic development. However, what is common is the search for ways to improve the efficiency of water production and use, as well as mitigate the impacts of factors affecting water availability, including climatic conditions, natural disasters, demographic changes and urbanization, technological advancements, economic growth and prosperity, and social and cultural values [*UNESCO*, 2012].

Researchers attempt to forecast how these drivers will evolve over the next decades and what measures should be taken by consumers and policy makers in order to address the water-related hurdles and develop a vision for a sustainable use of water resources. In such an attempt in 2011, the experts of the International Water and Sanitation Center note that "*water sector operates in a dynamic environment of rapidly changing levels of economic development, demographic change and governance contexts that have significant impacts*" [*IRC International Water and Sanitation Center*, 2011: 3] and note that trends in the sector are very uncertain.

Concerning the availability of water resources, Russia is one of the countries, which is relatively better positioned compared to a number of other countries in the world. However, there are still outstanding issues linked to protection and use of water resources, purification processes, water networks, consumption patterns, discharge, treatment and re-use. The present research recognizes that strategies for water resources should be covering the whole life-cycle approach in a holistic manner. Therefore, three inter-related domains have been identified to address different aspects of exploiting water resources: (i) sustainability of water supply systems; (ii) water use by households and industry; and (iii) new water services and products.

The project involves a fully-fledged Foresight process, which begins with a horizon scanning exercise, and continues with future scenarios and strategies for action. The current paper presents the outcomes of the scanning phase, which involves the analysis of trends, weak signals of future changes, uncertainties and wild cards in the form of largely unexpected but potentially vital developments in water resources. The scanning process began with a systematic analysis of Social, Technological, Economic, Environmental, Political and Value/Culture (STEEPV) systems to understand the dynamics of change in water resources. A global scanning was carried out with the review of publications and reports by acclaimed international and national bodies such as UNESCO, OECD, and the EU. The results were discussed and elaborated with the experts from Russia, Brazil, India, the USA, Japan and other countries through a scanning workshop held in Moscow in November, 2014.

The paper begins with the review of the key issues and challenges for water resources. Particular attention is paid to the state-of-the-art in the aforementioned three domains identified in the scope of research. The third section details the scanning methodology used for research. Trends, weak signals and wild cards identified are presented in the fourth section. In the following section the implications of those trends, weak signals and wild cards on water resources in Russia are discussed. The final section of the paper draws overall conclusions and outlines the project's next steps and follow-up activities.

1. Background

Despite its criticality as a natural resource, today water is not accessible and readily available, particularly for industries and people living in urban areas. Therefore, water has to be supplied for use for various purposes, and this makes it to be considered as a commodity. Water products and services have certain costs and markets rapidly develop. On the other hand, people have the right to access and use water "for free". This creates a complexity, and frequently, conflict in the utilization of water resources.

On 28 July 2010, through Resolution 64/292, the United Nations General Assembly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realization of all human rights [*United Nations*, 2010]. When it comes to enforcement of this human right, UNESCO [2012] distinguishes between the following categories of water consumers:

1. ecosystems, whose water demands are determined by the water requirements to sustain or restore the benefits for people;
2. energy, for which large quantities of water are used, but rarely reported and thus are poorly known;
3. food and agriculture;
4. human settlements, which includes water for drinking and household use; and
5. industry.

These five categories will constitute a necessary scope for the analysis of trends, wild card, which are likely to shape the sustainability of water systems, water use by households and industry, and new water products and services. Therefore it is important to set the scene in each category in order to understand the current context and what is likely to emerge in the future within that context.

The amount of water use has been growing at an alarmingly high speed over the course of the last century. It is projected that **global water demand will increase by 55% in 2050** in comparison with the level in year 2000. Specialists forecast that by the year 2050, 3,9 bln people (or approximately 40% of world's population) will face in serious limitations to their water consumption. About 240 mln people will not have sufficient access to drinking water, and 124 bln people will not have appropriate facilities for water disposal (i.e. will have inadequate sanitary conditions) [*OECD*, 2012a].

Water and Energy domains are inextricably interlinked. Whilst water is crucial for the production, distribution and use of energy, energy is crucial for the extraction and delivery of water. As the drivers of human health, economic growth and environmental sustainability, development of long term water and energy strategies are crucial. At present, increased global **water consumption is also linked to the increased global energy consumption trend**. According to the International Energy Agency (IEA), in 2010, 15% water of the total water consumption was spent on electricity production, which makes up 75% of water resources consumption in the industrial sector [*OECD*, 2012b]. As global industrial production is expected further grow, it will continuously require more electric power, and, thus, more water. Therefore programs aimed at the reduction of water resources consumption (deficit) should also include energy efficiency measures.

Water – food – agriculture nexus is also crucial as water is one of the key inputs in the entire agrifood supply chain. Agriculture is currently the largest user of water at the global level, accounting for 70% of total withdrawal [*FAO*, 2011]. Water scarcity and decreasing availability of water for agriculture constrain irrigated production overall, and particularly in the most hydrologically stressed areas and countries [*UNESCO*, 2014]. Excessive use of water for irrigation leads to degradation of farmlands; causes rise of groundwater level and secondary soil salinization. As a result, salted soil is inappropriate for agricultural use. On the other hand, by 2050 there will be much less water left for irrigation, as it will compete with other human needs.

Demand for water resources in both urban and rural settlements has been increasing dramatically. A substantial part of the world population does not have access to clean water and/or water disposal systems (a pre-requisite for proper sanitation). UN experts estimate that the Millennium Development Goal (MDG) for sanitation will not be attained by 2015. Moreover, by 2050, 1.4 billion people, mostly in developing countries, are projected not to have access to basic sanitation [*OECD*, 2012a]. The UN estimates that 11% of humanity (0.8 Billion) cannot access safe water, 17% of humanity (1.2 Billion) live where water is physically scarce, 22% of humanity (1.6 Billion) face economic water shortage (inadequate infrastructure/cost) and 36% of humanity (2.5 Billion) still lack basic sanitation [*United Nations*, 2013]. Considering the rapid urbanization process, particularly in Africa, South Asia and China, it may be expected that cities will be the main sources of crises in water as well as food and energy.

Industry is one of the main users of water, which is used in production processes, e.g. for heating, cooling, cleaning/washing, manufacturing, extracting etc. Industrial water is either provided by a public/private supplier or self-supplied through making use of available ground- and/or surface water resources. Moreover, industry is one of the major water polluters. Unfortunately, not all industrial water is treated before disposed into nature. Water withdrawals for industry currently represent 22% of total water use with 59% in high-income countries and only 8% in low-income countries. In 2025, the industrial withdrawal is expected to represent about 24% of total water consumption [*UNESCO*, 2014a]. 70% of industrial waste is dumped into untreated water in developing countries.

The present research recognizes that strategies for water resources should be covering the whole life-cycle approach in a holistic manner. Therefore, three inter-related domains have been identified to address different aspects of exploiting water resources: (i) sustainability of water supply systems; (ii) water use by households and industry; and (iii) new water services and products. These three domains cover the five categories identified by UNESCO on the demand side as well as the supply side ranging from the nature, state, and utility companies responsible for supplying water to the users. Thus, the present study considers the scope of the three domains as follows:

The "sustainability of water systems" domain in this study encompasses climate and water resources, surface and ground water sources and their condition, management of water resources in hydrolic engineering systems, transboundary water governance issues, economy of water resources, recycling and reuse of water and its "micro" and "macro" purification, and cross-sectoral water issues.

The domain, "new water products and services", the study considers water industry challenges that create demand for new products and services, which are universal. The following topics are considered in this sub-category: institutional (public and private ownership of water and water systems; international financial institutes and water reforms and water tariffs), regional and national water use (groundwater use; water storage; water-energy-food nexus; and culture of water use) and client-oriented products and services (water and wastewater treatment).

Finally, "Water use by households and industry" covers issues linked with changing society and lifestyles and the economic development. The term 'water use' refers to the amount of water used by an individual, community or a nation for a certain task or need.

Following the scoping of the domains, the next section of the paper describes the research methodology.

2. Methodology

The Foresight project on Water Resources aims at:

- Considering trends, drivers and uncertainties in water supply, demand, use and re-use with a particular focus on:
    - Sustainability of water systems
    - Water use by households and industry
    - New water services and products
- Explore emerging opportunities and threats for the future and assess their implications
- Present strategies and actions with emerging technologies, applications, and new business models for water supply, transfer and use.

The research methodology of horizon scanning, presented in this paper involves the identification of the key trends, drivers and uncertainties along with the identification of Weak Signals of future emerging trends, and Wild Cards in the forms of future surprises, shocks and other unexpected events, which may disrupt the future of the Water Resources sector. By identifying key developments and uncertainties the scanning phase of the study provides a background for the development of future scenarios, which is the key activity of the second phase.

As the first deliverable of the project, this paper develops and presents a set of "Global Trends in the Water Sector". Scanning is defined as by the UK's Chief Scientists Advisers' Committee (2004) as:

"*... the systematic examination of potential threats, opportunities and likely future developments including but not restricted to those at the margins of current thinking and planning. Horizon scanning may explore novel and unexpected ideas as well as persistent trends and issues*" [*DEFRA*, 2002].

Trends typically involve those change factors that arise from broadly generalizable change and innovation. These are usually experienced by everyone and often in similar contexts. Trends characterize broad parameters for shifts in attitudes, policies and business focus over periods of several years that usually have global reach. They may be larger than the power of individual organizations and sometimes nations [*Saritas, Smith*, 2011]. Issues may be the threats, opportunities or a mixture of them related to trends, underlying processes, possible events, and other future developments. In most cases Horizon Scanning goes beyond the identification of trends and issues to cover drivers of change as enablers of trends, weak signals of emerging future change, wild cards of potential high impact but low probability events. Most organizations and even nations need to collaborate in order to change, exploit or mitigate the implications of all these expected or unexpected events and developments.

In the present study, the STEEPV framework was used to map trends identified to ensure that a broad range of trends are covered, which may be stemming from various factors in the overall Water Resources landscape. The set of categories is intended to be sufficiently wide-ranging and comprehensive to consider a wide variety of inter-related and inter-dependent issues (Figure 1). It is not a rigorous conceptual framework, but rather a set of categories that have proven to be useful for stimulating broad thinking or convenient for classifying topics, trends or drivers.

Figure 1. STEEPV framework with examples of what is covered under each category

Social	Ways of life (e.g. use of leisure time, family living patterns), demographic structures, social inclusion and cohesion issues (fragmentation of lifestyles, levels of (in)equality, educational trends).
Technological	Rates of technological progress, pace of diffusion of innovations, problems and risks associated with technology (including security and health problems).
Economic	Levels and distribution of economic growth, industrial structures, competition and competitiveness, markets and financial issues.
Environmental	Pressures connected with sustainability and climate change, more localised environmental issues (including pollution, resource depletion, and associated biodiversity, and welfare concerns).
Political	Dominant political viewpoints or parties, political (in)stability, regulatory roles and actions of governments, political action and lobbying by non-state actors (e.g. pressure groups, paramilitaries).
Values	Attitudes to working life (e.g. entrepreneurialism, career aspirations, deference to authority, demands for mobility (across jobs or places, etc.), preferences for leisure, culture, social relations, etc.

The Scanning work within this project involved a mixture of methods involving scoping, desk research, expert meetings, STEEPV analysis and brainstorming activities. First, a scoping exercise was undertaken in August 2014 to clarify the focus of the activity. Three thematic areas were identified during the scoping meeting (i.e. Sustainability of water systems; Water use by households and industry; and New water services and products). A scoping document was prepared describing each thematic area in detail. Second, a review activity was undertaken to identify trends in global, international and national references and strategy documents. The identified trends were detailed by the experts from the perspective of three areas of the project to be presented at the international expert seminar.

The reviewing process also involved the identification of international and national experts with particular competence on the three themes. Following the nomination of experts, the workshop "Global Trends in the Water Sector" was held on November 7th, 2014. The workshop involved the presentation of the project goals and methodology. The team members presented the three themes and the trends identified under each of them. The international experts from the US, Japan, India, Moldova and Belarus gave presentations on the international perspectives on the three themes.

A brainstorming session was undertaken to discuss the trends under each of the three themes. The international and national experts had an opportunity to review the lists of trends and to complement them with their knowledge and experience. Two key questions were asked to the experts for consideration:

1. What are the trends, issues and uncertainties in the water sector in each theme?
2. What would be the implications for Russia?

A STEEPV framework was generated to map the trends under relevant categories and to indicate the systemic relationships between them. The expert meeting was concluded with a discussion on possible implications of the trends for Russia.

The current report presents the selection of key trends identified by the project team, and complemented and validated by the expert panel. In the following sections of the paper, first, trends will be presented followed by the discussion of them in the context of Russia. The paper will be concluded with a discussion and future work to follow up.

4. Trends, weak signals and wild cards for Water Resources

Following the scoping workshop and definition of the focus and coverage of the three domains, a preparatory work was undertaken through expert consultations and reviews. The results of the preparatory work were presented at the scanning workshop by the respective experts in three domains. This was followed by the presentations by invited international speakers with the focus on the some domains. A list of trends was generated based on all the presentations and through a brainstorming session by using the STEEPV framework to address different aspects of water resources. The list of trends generated is presented below (Tables 1-6).

Table 1. Social trends

- Water challenges for the poorest people are persisting. Problems with sanitation and waterborne diseases
- Health impacts of water treatment technologies (e.g. use of chlorine and chlorine compounds during the drinking water treatment)
- Increasing risk of water-related conflicts between countries
- Increasing demand for freshwater due to global population growth
- Public and private ownership of water and water systems may go in conflict with human right to water
- Motivation for more rational use of water (not to be considered as somebody’s own or free good)
- A significant part of the World population does not have an access to a stable water supply, which creates environmental refugees (i.e., North Africa) and water terrorism

Russia’s trends

- The quality of drinking water in water supply systems in Russia and post-Soviet countries often do not meet sanitary standards and raises consumer concern. A significant part of the population use household filters or buys bottled water
- Absence of water-supply and organized water disposal in significant number of the Russian settlements. In some cities water supply is available only several hours per day
- Increasing demand for water in Russia. It has already decreased almost two times over the last 10 years (~from 300-380 to 180-200 liters per person per day) while it is constantly increasing around the world (European level is 120-150 liters). This is largely a result of introducing metering systems and widespread installation of modern plumbing

Table 2. Technological trends

- Increasing efficiency of water use through technologies for water saving. Technologies for treatment and recycling of water and promotion of zero-discharge
- Increasing availability of water cleaning and filtering technologies
- The implementation of centralized information systems for measuring resource use (beyond meters)
- The widespread use of smart metering and payment technologies to enable variable tariffs for different users
- Differentiation of water supply technologies for small settlements and big cities. The challenge of water supply in rural areas and poor cities’ suburbs still exists: a connection to major water pipes and water treatment systems becomes very expensive, small-scale systems usually cannot provide a similar level of water quality
- Increasing efficiency of irrigation technologies
- Technologies enabling 100% water desalination for drinking purposes. Quick cost-cutting of desalination technologies and processes enhances rising demand for desalinated water
- Solar desalination has already allowed to decrease costs of desalinated water twofold and there are strong estimates that there are additional possibilities to cut the price further down as much as 3-4 times
- Membranes continuously replace chemicals. Particularly forward osmosis technology is a new promising form of water desalination and treatment
- In regular water purification, chlorine will be gradually replaced by Ultra Violet (UV) disinfection
- A volume of water that evaporates from reservoirs exceeds world domestic and industrial water withdrawal. Evaporation challenge makes countries build mid-scale reservoirs and develop chemical covers and leak proof puddles
- Water resources consumption is increasing due to increased energy consumption. Thus the most promising and cost-efficient technologies are combo water-energy solutions based on water re-

use in the energy sector

- Nuclear desalination for small and mid-sized reactors becomes one of the most attractive «tandems» in water-energy nexus

Russia's trends

- Insufficient wastewater treatment in the majority of Russia's industrial enterprises and utilities leads to the deterioration of water facilities. The deterioration of the Russian water supply-disposal infrastructure exceeds 60%, which causes relatively low technological efficiency and higher number of accidents. It is necessary to replace about 5% of pipeline routes per year, while in Russia a little more than one percent is being replaced

Table 3. Economic trends

- Greater competition in goods and services in the water market
- Design of new, more customized business models in water management. For example: due to limited water availability in San Paolo 60% of companies in textile moved to other regions
- Wider application of future-oriented risk analysis of water-dependent sectors
- Priority development of water-intensive sectors
- Wider application of techniques for mapping and measuring the level of government investment
- Increasing availability of financing for industrial and urban water cleaning
- Increasing water export and trade of 'virtual water' between water-supply and water-deficit countries
- Water-consuming shale gas extraction and hydraulic fracturing turn into a broadly discussed issue because water stressed countries search for alternatives
- As far as world business leaders pay more attention to water management and use it as a PR tool, eco-friendly water treatment and use will soon provide an extra market value for firms
- In developing countries the water sector ranks third in investment attractiveness in infrastructure after transport and energy

Russia's trends

- Adoption of long-term tariffs (starting 2016) for water supply-disposal services in Russia. Although this is a positive development, it is insufficient to make the water sector attractive for investments as frozen tariffs may not be desirable
- The Russian water sector has some positive improvements in the performance of measures with a short pay-off period, e.g., energy service contracts related to the installation of private meters and optimization of the hydrodynamic modes of payment in order to save money on electricity bills
- In Russia there are institutional problems in the water supply to apartment houses after the switch to metering systems. After the apartment owners purchase the meter for the entire apartment house, water supply companies loose access to it
- Russia's water utility enterprises debts steadily grow due to decreasing tariff revenues and inadequate presentation of technological losses

Table 4. Environmental trends

- Increasing pollution of water basins – rivers, ground water, etc., especially in the developing and under-developed countries
- Climate change, desertification, and ice caps melting. Higher frequency of extreme weather phenomena, floods, droughts.
- Widespread adoption of the "0-discharge" concept, i.e. no water is discharged to rivers, but repeatedly treated and re-used
-
- Critical levels of groundwater around industrial areas
- The number of people who are under the risk of flood is gradually increasing
- In Asia 90% of disasters are related to water
- Increasing concerns related to transboundary water pollution
- The deterioration of hydraulic structures and reservoirs increase the risk of disasters especially in flooding periods
- Environment unfriendly virtual water flows (national, international and global trade transfers water from [often dry] rural areas to higher population urban centers)
- New canals, dams and reservoirs provide water for economic use but at the same time, a displacement of huge amounts of water can destroy local fisheries, farming, and traditional recreation zones.

Russia's trends

- In Russia and post-Soviet countries insufficient water treatment leads to serious environmental consequences
- Chinese market opens up for Russian water products
- Increasing threat of water deficit for Russia's Eastern water basins due to large consumption by the neighboring China's industries
- Seasonal changes in water supply (e.g. water accidents in Central Russia)
- The excess rate of groundwater spending compared with the rate of replenishment. The exhaustion of groundwater gradually becomes a threat to sustainable water supply in some regions.
- Increasing volume open waste water in cities with 'micro-pollutants' (i.e. rain water from cities containing chemicals including medical waste, used cosmetics, dyes) pollute water sources.

Table 5. Political trends

- Although governments are often involved in water regulation (in particular, through strategy-making and promoting innovations), the public sector is usually slow in catching up on trends (for example, Brazil missed such an opportunity and now imports all the equipment for water treatment from China, Finland)
- Increased competition for water in transboundary river basins are characterized by escalation of tensions in political relations and even water-related conflicts
- Privatization of water supply companies
- Multiple water stakeholder collaboration
- Service policies for big/small towns
- Introduction of new normative and tariff policies with diversified regulation
- Changes in the legal basis for water management

Russia's trends

- Critically low cost of water supply and disposal services in Russia and post-Soviet countries
- Water supply-disposal companies' tariff regulation in Russia and other post-Soviet countries is often normative (heavily influenced by the government)
- Development potential of public-private partnership as competition for the monopoly market. Currently, the market share of private water supply operators exceeds 20%. However, it has not

led to significant changes

Table 6. Value / Cultural trends
• Changing lifestyles and water consumption patterns. Increasing quality of life is usually considered to be associated with higher water consumption • Changing attitudes towards state policy and complying with it • Water is considered to be a free good, a gift of nature, especially in rural communities that do not have water meters. It leads to a permanent wasteful water use and will eventually lead to local crisis situations
Russia's trends
• Irrational water resources use for industry and agriculture in Russia in comparison with the European Union and the USA gradually creates water resources deficit, escalated in several regions of the country

Following the discussion on the trends in each category, the participants of the workshop were invited to prioritize the topics for further elaboration. During the first round of discussion and prioritization a total of 25 trends were prioritized out of 60 presented above. The shortened list included 9 trends related to sustainability of water supply systems; 7 trends for water use by households and industry; and 9 trends for new water services and products. These are elaborated further in the next sections of the paper. Following the descriptions through a second round of prioritization, three trends were selected under each domain, which will be given in a table at the end of each section below.

4.1 Sustainability of water systems

It is projected that **global water demand will increase dramatically in the future** (by 55% in 2050 in comparison with the level in year 2000). This will require makes water sector to rank third by the volume of attracted infrastructure investment after transport and energy. World Health Organization's (WHO) study for quantifying the impact of projects aimed at advancing water quality, identified the main **economic benefits of investments in drinking water purification**. The overall gain projected by the WHO equals to USD 84 bln per annum. The breakdown of the key impacts from achieving the MDGs for water and sanitation are presented below in Table 6 [*Hutton, Haller*, 2004].

Table 7. Overall benefits of achieving the MDGs for water and sanitation

Types of benefits	Breakdown	Monetized benefits (in USD)
Time saved by improving water and sanitation services	+ 20 billion working days a year	USD 63 billion a year
Productivity savings	+320 million productive days gained in the 15-59 age group 272 million school attendance days a year 1,5 billion healthy days for children under five	USD 9,9 billion a year
Health-care savings		USD 7 billion a year for health agencies USD 340 million for individuals
Value of deaths averted, based on discounted future earnings		USD 3,6 million a year
Total benefits		**USD 84 billion a year**

Sources: [*OECD*, 2010; *Prüss-Üstün et al*., 2008; *Hutton, Haller*, 2004].

The main difficulty on the way to a more efficient water use is the insufficient volume of investments in the water sector. The main difficulty in attracting investments is that despite the expected high returns, investor and beneficiary are usually different persons. As one may conclude from the Table 6, the added value of the water investments is gained not only by end users, but the society as a whole; the government saves money on emergency costs, tourism is advancing, healthcare system becomes more efficient. It is nearly impossible to channel these benefits in the form of dividends to a particular investor.

There is a growing need for investment in **global water infrastructure** that surpasses similar cumulative investments in traditional physical infrastructure (roads, railways, telecommunication and energy distribution). This is due to the prolonged exploitation and the lack of ongoing recovery of water basins (especially in cases of ponds and agricultural sector reservoirs), the deterioration of hydraulic engineering units, and siltation of water reservoirs.

Data for several world regions indicate that in the course of the last 40 years the rate of **groundwater consumption** has **surpassed the rate of** its **replenishment**. The groundwater depletion is gradually becoming a threat to sustainability of water supply in some regions: it has doubled and reached approximately 280 kilometer cubed in 2000 (for comparison: in 1960 that figure was about 130 cubic kilometers). For instance, greater ground water use at the coastal areas leads to groundwater salinization, which complicates their use for drinking water supply [*Wada et al,* 2012].

Natural disasters pose a substantial threat to many countries. It is expected the number of people who are under the risk of flood will increase from 1.2 in 2010 to 1.6 bln in 2050, and the economic value of assets under the risk of flood will rise by 340% (up to 45 trln USD) during the same period. Moreover, the frequency of extreme weather phenomena, floods, droughts are expected to be higher due to climate change [*OECD*, 2012a] and this requires creation of a system of sustainable water supply in the regions mostly affected by fluctuations, i.e. water storage facilities as well as water pipelines should secure water needs in suffered regions.

Accidental water pollutions, such as unauthorized discharge, pipeline breakouts, and accidents at oil wells are often complimented by the so-called ‘micro-pollutants’ (i.e., medical waste, used cosmetics, dyes) that accumulate at water sources gradually. **Insufficient wastewater treatment** in the majority of industrial enterprises and utilities is yet another reason for the deterioration of water facilities and eventual pollution.

Sustainability of water systems is an important factor for preserving water ecosystems and **fishery stock**: among negative impacts are nitrogen and phosphate fertilizers from crop fields, eutrophication processes. OECD notes that badly designed agricultural and fisheries subsidies could further stress land, water and ecosystems.

Water is scarce and water basins and systems are not always within boundaries of one country. The **transboundary** nature of **water basins** have important consequences for their **governance** and may lead to political tensions and non-efficient distribution of water resources [*United Nations*, 2013a]. Mesopotamia, Nile, and Amu Derya basins can be considered among the most vulnerable areas for conflict [*Peek*, 2014]. Imbalance, and eventual problems, in the distribution of water resources are observed within the boundaries of individual countries too, such is in the Amazon basin. Substantial differentiation between groups of countries occurs in the rational water use (quantitative attributes) and the condition of water resources (qualitative attributes) [*Soncini-Sessa*, 2007]. OECD member-countries show positive dynamics in indicators reflecting both rational water use and condition of water resources, unlike other groups of countries, including the BRICS [*OECD*, 2012a].

Furthermore, we note the **absence of regulations and mechanisms for the functioning of the water market** in the (inter)national distribution of water-intensive products manufacture, and diversion of runoff.

Improved water management is essential to regulate competition for water needs among urban and rural regions, industries, energy producers, and ecosystems. In the absence of proper water management, water availability may become a major problem already in 20 to 30 years from now leading to lost opportunities, health and environmental damage [*OECD*, 2012a]. Among the persistent problems of water resources management is weak management of water basins, including incomplete set of criteria used for taking decisions on the distribution of water resources among users.

The key trends in sustainable water systems are related to climate change, non-efficient water resources distribution and water management (Table 7).

Table 8. Trends in sustainable water systems

Contribution	Trends
Climate change	• Higher frequency of extreme weather phenomena (floods, droughts, tsunami) deterioration of hydraulic structures, siltation of reservoir, for ex. increased number of people and volumes of property under the risk of flood • Negative impacts on water ecosystems, fishery, fishery, agriculture, water transport sector, etc. • Problems with natural groundwater replenishment
Non-efficient distribution of water resources	• Increased demand for water around the world due to growing population and economic growth, leads to increasing competition for limited water resources. Lack of effective market institutions lead to inefficient allocation of water resources among different industries and sectors of economy, between countries for trans-boundary water basins and between (groups of) people • Growing share of world population with lack of access to drinking water and appropriate water disposal • Lack of international regulation and mechanisms for 'virtual water' trade
Water management	• The rate of groundwater use does not march the rate of its replenishment • Ineffective control over water pollution leads to water contamination, including 'micro-pollutants' (i.e., medical waste, used cosmetics, dyes) • Lack of investment in water infrastructure • Deterioration of hydraulic structures and siltation of reservoirs

4.2. Water use by households and industry

A substantial part of the world population does not have access to clean water and/or water disposal systems (a pre-requisite for proper sanitation). In the course of the past 10 years, we have seen an **increase in global water demand and consumption**. During this period an opposite trend was observed in Russia. The sales volume of water-sewage utilities has decreased nearly twofold. This is partly a consequence of the introduction of own water use systems by large industrial consumers, and a result of widespread installation and meters and modern plumbing equipment in housing sector. Thus, average water consumption by households in Russia has gone down from over 300 liters per person per day (in Moscow from 380 liters) to 180-200 liters. However, there is still some way to go to reach the level of European average - 120-150 liters per person per day [*Russian Federal State Statistics Service*, 2013].

While in developed countries there are growing concerns over the **renewal of main water supply and disposal infrastructure**, in the New Independent States (NIS) of Eastern and Central Europe and Central Asia (EECA) (including some parts of Russia), the quality of drinking water in water supply systems often does not meet sanitary standards and raises consumer concerns (a significant part of the population use household filters or buying bottled water). Consequently, in the NIS EECA countries there is a growing number of cities where waste waters undergo at best only mechanical purification, and in many cities clean water is supplied only in certain hours.

Unlike energy, manufacturing, and housing, **irrigation is expected to suffer dramatically** from structural changes in water consumption. Considering that in the next 35 years the overall water demand is projected to increase by 55% and 40% of the world's population are projected to live in water-stressed areas [*OECD*, *2012a*: 208] by 2050 there will be much less water left for irrigation, as it will compete with other human needs.

Today we see wide industrial application of new water treatment technologies with use of **low pressure membrane technologies** (i.e. in secondary use in Singapore, desalination in Israel, etc.). Compared to other technologies with the same effect (i.e. biomimetic nanosystems), these technologies have the biggest scale of use. They are widely discussed at business and research fora[5] and by specialized research centers[6]. The greatest installed volume as of 2008 has occurred in the Americas (44% in the US), 19% in Europe (including Eastern Europe and a few in neighboring states), and 23% in the Pacific Rim [*Furukawa*, 2008]. In 2012, the US Department of the Interior published experimental results of a data-driven analysis to evaluate the technical and economic factors that impact lifecycle costs for low-pressure (microfiltration and ultrafiltration) membranes. The researchers quantified differences in the fouling propensity for an alumina ceramic and a polyethersulfone (PES) polymeric ultrafiltration membrane [*Guerra*, *Pellegrino*, 2012]. Generally these technologies are expensive and only cost-effective if payments for water use are sufficient to cover the costs. For instance, the cost of water supply and disposal services in Russia and NIS EECA countries is critically low, which often leads to bankruptcy of the water supply enterprises, especially in towns / small settlements. Water cubic meter in the Russian water supply system costs less than RUB 30 (in 2013), which is cheaper than a half liter bottled water.

Furthermore, water **tariff regulation** methods applied to water supply and wastewater disposal companies in NIS EECA countries is often done based on political (social) rather than economic considerations. For example, in calculating expenditures the companies take into consideration normative losses (instead of not actual losses). This distorts the real picture: if losses are insignificant, why upgrading the networks?

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[5] Such as the conference "Advanced Membrane Technology VI: Water, Energy, and New Frontiers" (ECI Conference Series) to be held in February 2015 in Italy.

[6] Such as UNESCO Center for Membrane Science and Technology at the University of New South Wales, Australia.

Trends in individual and industrial water use could be grouped into those, related to water infrastructure and tariff policy, those liked with investment policy and institutional ones (Table 8).

Table 9. Trends in household and industrial water use

Contribution	Trends
Water infrastructure and tariff policy	• Ineffective policy instruments or implementation oversight lead to industrial enterprises discharging wastewater outside proper disposal systems. Lack of funds for renewal of main water supply and disposal infrastructure • Scale optimisation of water supply enterprises and their activities (to overcome the inefficiency of water services in small towns and settlements) • Most countries face the need to renovate (replace) capital equipment, both production and infrastructural • The price of water supply and wastewater disposal in Russia and the former Soviet countries is extremely low • Tariff regulation of water supply and wastewater treatment in Russia and the former Soviet countries has political (rather than economic) reasoning • Wasteful water consumption patterns among population and households
Investment policy	• Advancement of public-private partnerships (developing countries) and public sector borrowing (developed countries) • In Russia the 10 years of PPP experience there is no statistically significant difference in enterprises' performance as compared to other institutional alternatives • Remunipalization of water supply and disposal enterprises in Europe
Institutions	• «Regionalization» of water business: horizontal vs vertical • Institutional problems in the water supply to multi-apartment houses, including metering and connection to water supply systems by developers

4.3 New water products and services

Researchers note slow evolution of **water use culture**, which implicitly defines a wide range of aspects within water use among households. Even the developed countries apply a combination of measures, including tariff regulation and intense PR and awareness rising campaigns promoting water-friendly equipment (for example double-splash toilets) to change water-use practices. Given the global urbanization trend this cultural aspect plays a continuously growing role.

The use of chlorine and chlorine compounds during the drinking water treatment in some countries (including many Russian cities) increase the risk of morbidity. However for **least-developed economies** implementation of basic treatment (even individual chlorine purification) and development of simplest irrigation systems could have a profound effect on economic growth and contribute to a better healthcare.

The costs of access to clean water increases in many countries around the world following the escalation of water stress. For an individual, water use it means lower quality of life and there is a high degree of uncertainty associated with the establishment of property rights on water. For municipal water use it means that rural areas and slums are weak competitors for scarce water resource, and it poses a huge social problem. Among industrial and agricultural water users enhanced cross-industrial competition for water creates a need for higher productivity. Technology solutions aimed at resolution of this challenge are directed towards **design of new less water-intensive production processes and equipment**.

There is a direct relation between financial support (mainly credits, but also grants) provided by international financial institutions and the requirement for privatization of water services. It may create substantial social risks (which have to be carefully evaluated) in **developing countries** with large share of poor population. The most famous example is a so called Water war in Cochabmba, in Bolivia [*Olivera, Cochamabma*, 2003; *Nickson, Vargas*, 2002; *Spronk*, 2007].

Developing countries face the operating costs vs. capital expenditures dilemma: in the past years many of them have gradually raised water tariffs. However, this additional money is spent to cover growing operating costs. Thus it creates an endless circle: obsolete water capacities require higher operating expenses and money gained from tariff` increase is not used to make capital investments to modernize the water supply systems. Freezing of tariffs, in contrast, makes water sector unattractive for investors.

The trade of real water between water–rich and water-poor countries is usually impossible due to long distances and associated high costs, while the **trade of 'virtual water'** happens often. The 'Virtual water' contained in the product, first introduced by Tony Allan in 1993 [*Allan*, 1993; 1994], is the water used for the production of an agricultural or industrial product. Thus, if a country exports a water-intensive product, one may say that it exports virtual water. In this way some countries satisfy the water needs of other countries [*Hoekstra*, 2002]. Most importantly, virtual water may become an alternative source of water, but it needs to be wisely used. The current trend is international trade of ‘virtual water’ (in the form of water intensive products) between water-scarce and water-rich countries. However, it is often the case that national, international and global trade transfers water from (often dry) rural areas to higher population urban centers. The existing studies estimate global virtual water trade between nations to be from 1340×109 m3 (in 2000) to 683×109 m3 per year [*Hoekstra and Hung*, 2002, 2003; *Chapagain and Hoekstra*, 2003; Oki et al., 2003]. These important developments make researchers talk about the water footprint [see for ex., *Ercin*, *Hoekstra*, 2014; *Mekonnen*, *Hoekstra*, 2011]. The virtual water consumption by industry and agriculture is presented in Table 9.

Table 10: Actual and virtual water consumption in selected countries, 2006-2014

Nation	Per Capita Withdrawal (Liters/p/y)	% Domestic	% Industrial ("virtual water")	% Agriculture ("virtual water")	Year
Brazil	297,000	28	17	**55**	2006
Russian Federation	546,000	19	**63**	18	2000
India	627,000	7	2	**90**	2010
China	425,000	12	23	**63**	2007
USA	**1,518,000**	13	**46**	41	2005
Japan	696,000	20	18	**62**	2000
Germany	463,000	12	**68**	20	2001
Worldwide	681,358+	10	20	**70**	2014*

* Worldometers, 2014, annualized from. Jan 1-Nov 6, 2014, UN statistics.
Sources: [*Gleick et al*., 2011**]**

What is important indeed is the dawn of the actual (not virtual) water trade. Pure water seems to become a tradable good in this century. Experts expect that in the middle of 21st century fresh water from the lake Baikal may replace petroleum in the structure of Russian exports. This may be the threat for sustainability if greed prevails over rationality.

The **climate change** makes dry areas become dryer and warmer, and other regions, especially tropical ones, face more frequent and large-scale floods. Another consequence of climate change is higher probability of natural disasters: since the 1950s, the number of natural disasters has risen exponentially and water-related disasters (either droughts or floods) represent more than one third of the total. This challenge **requires considerable adaptation of existing water systems** – building new reservoirs, improving flood management and developing anti-evaporation and leak-proof technologies.

The abovementioned UN resolution on human right to water and sanitation is a great human rights achievement, and, at the same time, a limitation for **market mechanisms of water-pricing and intensive privatization** as advised by the World Bank. For many developing countries, the World Bank funds represent a unique opportunity to renovate their obsolete water systems. For instance, in Bolivia, Philippines and Tanzania quick liberalization of water industry led to serious conflicts between poor population and local authorities. Thus, a human right to water may represent a constraint for investors.

Developing countries face the biggest challenges in water use and management – almost all of them experience water shortage, deteriorating environment and fast urbanization. China and other developing countries have to solve several problems simultaneously: develop large-scale infrastructure projects, establish or modernize municipal water systems and increase water sector productivity. At the same time those countries ought to rebalance their water use structure and upgrade respective institutional regulations for national and trans-boundary basins.

Developed countries are the major producers of water-related technological innovations and have the most advanced water-use policies. This is true for Europe (European Water initiative), Asia (with Singapore best-practices) and North America (International Joint commission that manages US-Canadian Great Lakes). Groundbreaking water treatment and recycling technologies and eco-neutral infrastructure projects represent the main focus of innovative water technologies in those countries.

The main principle of the water sector organization is conservatism, given its social implications. Internationally there are various **legal forms that water supply and wastewater disposal enterprises** assume. In developed countries public enterprises dominate the picture:

- "German model" with joint-stock companies, usually owned by local authorities;
- "French model" with high share of public-private partnerships;
- "England model" with water supply infrastructure privatized on the basin principle (not by the settlement principle).

Furthermore, in continental Europe investments in the sector are usually attracted through public borrowings (i.e. municipal bonds), even in the case of public-private partnerships (PPP). The reason for this is rather pragmatic: public borrowing is cheaper than private. Of fundamental importance is that investments are rarely made from the current budget and loans are paid back due to economic activity of the water supply enterprises [*Mandri-Perrott, Striggers*, 2013].

In developing countries the main burden usually lies on the PPP contracts and private investment (due to high risk of budgetary borrowings) [*World Economic Forum*, 2005].

The overview of the state-of the art allowed us to narrow the research focus of the three topics on the following issues.

Policy makers should be aware of the way we have dealt with water use both historically and in the present. These insights are a good basis for assessments of water use by industry and households and water restrictions that feed into the new water management programs. By **mapping water use** and comparing it to economic value we can see where this limited resource is of most benefit to us. Moreover, it is necessary to monitor the flow of water from environment to the economy and back [*Australian Bureau for Statistics*, 2012].

The problem of **scale optimization of water supply enterprises** activities is common for many countries. In small settlements (towns) limited scale of activities leads to the lack of managerial and technical competence and to high unit costs (coupled with lower consumers' purchase power). In the European Union scale optimization is solved through establishing horizontal links, either by creating one inter-municipal company in several settlements through the merger of assets (e.g. Poland, and the Czech Republic), or by conducting inter-municipal competition for selection of a private operator for several municipal institutions (e.g. Romania). Some recent developments point to a "remunicipalization" of the public services sector, including water, that we may soon see in the European Union.

Emerging trends related to water **products and services** were classified by their main contribution. These trends are linked to either solutions increasing productivity or the volume of water resources, or aim to physically reallocate existing volumes of water. Trends in water products and services could be grouped into those that are aimed at attaining higher productivity as compared with existing solutions, provide users with additional resources and offer infrastructure solutions (Table 10).

Table 11. Trends in new water products and services

Contribution	Trends
Higher productivity	• Combo hydro-energy technologies • Water-saving technologies (bio-gas recovery systems, water meters, ultrasonic sludge pre-treatment, pipe rehabilitation and relining systems, and water derivative products like water-free toilets) • Increased competition from Asia (especially China) in higher-end of water products and services
Extra-resources	• Desalination (new methods, solar and nuclear options) • Treatment (UV and membranes *versus* Chlorine and other chemicals)
Infrastructure solutions	• Multifunctional dams • Small and mid-sized water reservoirs, chemical covers and leak proof puddles • Country–wide channels

5. Weak Signals and Wild Cards

The main trends that were identified above are the likely developments of the global water resources. However, they could be diverted or completely reversed by certain factors, which seem unlikely or are little known at present – weak signals and wild cards [*Saritas, Smith*, 2011]. The weak signals and wild cards, identified in the project, range from big ocean current shifts to pandemics that radically change water demand practices (Table 11).

Table 12. Weak signals and wild cards in the project's thematic areas

	Weak signals	Wild cards
Sustainable water systems	**Water loss/contamination** in aging urban pipes **Nuclear accidents contaminated aquatic food webs** in Chernobyl and Fukushima **"Freaky weather,"** like drought in nations' breadbaskets (i.e. California) **"Freakish" aquatic life:** intersex fish, mutant frogs and toxic shellfish	**Catastrophic contamination** of drinking water (e.g., by fracking or radiation) **Exotic pollutants bypass water treatment** (e.g., medicine, nanotech, pathogen) **Big ocean currents shift**, changing climate & weather across continents **Hydrosphere geo-engineering** (e.g., refilling Lake Chad, Dead Sea, and depleted aquifers)
Individual and industrial water use	**Illegal water taps** continue in urban slums The World **miss UN sustainable development goal (SDG) for sanitation** Thousands dying of **Ebola in West Africa** – *how many collected water for their families?*	**Society rejects cost** to give or sustain clean water for everyone everywhere "**Back to basics**:" demand drops for bottled water and virtual water-intensive products **Pandemic** changes water demands, limits water operating & maintenance capacity **Hydro-hegemons assert power or hydro-terrorists act** (e.g., IS in Iraq now) **Decentralized/on-site water harvesting, treatment & reuse** becomes viable **Hydrosphere geo-engineering** (e.g., refilling Lake Chad, Dead Sea, depleted aquifers)
Water products and services	**Hegemons have ignored water-sharing treaties and threatened international violence vs. neighbors**	**Energy-for-water trading** or water cartels become economically and politically viable **"Hot" superpower war** disrupts global trade, SDG investment and development aid **Hydrogen fuel cells' proliferate,** with pure water as byproduct

Source: [*Sklarew*, 2015].

No matter how improbable weak signals and wild cards seem, all of them are based on certain signals that need to be assessed. In mathematical models the probability of the phenomena occurrence may be calculated. For instance, extreme weather phenomena (i.e.

droughts, tsunami) are already predicted by private and state agencies based on satellite and other data with the use of special software.

6. Conclusions: implications for Russia, discussion and next steps

Based on the above analysis we conclude that the three topics identified for our study are complementary and overlap in a number of issues, including the impact of climate change and its consequences, the limitations to virtual and actual water consumption that require water-saving and water-reuse solutions and the differences in approaches to water management in different country groupings.

First of all, it can be said that Russia has sufficient water supply. The overall intake of water for drinking and economic purposes in Russia amounts to 3% of the total water resources 2/3 of which are discarded back to water bodies as discharge water. The country is among those with sufficient water supply with a little less than 20,000 m^3 of water per person per year (the UN Economic Commission for Europe defines countries with poor water supply as those with less than 17,000 thousand m^3 per person per year) [*UNESCO*, 2012a].

The water management measures target difficulties related to housing and sustainable development. The comprehensive policies should cover tariffs, infrastructure, investments and institutions. Every trend listed in this paper is linked to a set of related water management issues.

The specific products and services that may address the main trends and help solve the existing challenges are related to advancements of infrastructure, increasing the volume of water resources used (through previously unavailable resources or though re-use of existing stock) and their productivity.

Through our analysis we have identified five major challenges mentioned below for implementation of water-tech innovations in Russia and trends that create new opportunities for Russia.

A key systemic restriction in water use for the next decades relates to competition between agriculture, energy, biofuel production and water use. Given that the amount of renewable water resources is almost fixed and even decreases because of pollution, comprehensive solutions for water development will be required.

Drop irrigation turns into an imperative. This technology may entail a substantial decrease of costs due to high demand in new farmlands in Africa owned by Chinese, Indian and Middle East investors.

The challenge of water supply in rural areas and poor city suburbs is especially evident in large countries, like Russia: a connection to major water pipes and water treatment systems becomes very expensive and small-scale systems typically cannot provide a similar level of water quality. A substantial part of Russian settlements do not have a water supply and disposal system.

While the Russian water sector is not very attractive for investors. The Russian water sector has significantly less lobbying opportunities than other infrastructure sectors, which complicates its institutional and financial positions. Meanwhile, there have been some positive changes with regard to activities with a short pay-off period. In particular, it concerns the widespread of energy service contracts related to the installation of private meters and optimization of the hydrodynamic payment modes, the costs of which are covered due to electricity bills savings.

There are three steps that will be undertaken in the project next. First, a set of scenarios will be developed. Future scenarios for Water Resources will explore the alternative future for Water Resources. This phase will involve the analysis of existing water scenarios produced by a number of international organizations. First a set of synthesis scenarios will be developed based on the common assumptions of scenario sets. These will be used as a background for developing future scenarios for Water Resources in Russia. The scenario phase will be completed with the development of a vision. Second, strategies will be formed. Following the development of future visions and targets, the study will then focus on strategies and roadmaps for achieving that desirable future. Promising science and technology areas, and policy and strategy advice will be the main outcomes of this third phase. Third, the project team will proceed to dissemination and evaluation activities. This phase will be concerned with the generation of scientific, policy and educational outputs, awareness raising and reporting. An evaluation study will be undertaken to assess the work done and to develop ways of improving the practice and impact for the future activities to be undertaken by the Center for Advanced Studies.

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References:

Assies W. (2003) David versus Goliath in Cochabamba: Water Rights, Neoliberalism, and the Revival of Social Protest in Bolivia. Latin American Perspectives, Vol. 30, No. 3.
Australian Bureau for Statistics (2012) Year Book Australia 2012. Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1301.0~2012~Main%20Features~Water~279 (accessed 17.03.2015).

DEFRA (2002). Defra's Horizon Scanning Strategy for Science, Science Directorate, Defra Science Strategy Team. Department for Environment, Food and Rural Affairs. December 2002.

Ercin A.E. (2014) Hoekstra A.Y. Water footprint scenarios for 2050: a global analysis. Environment International 64, pp. 71-82.

FAO (2011) 'Energy-Smart' Food for People and Climate. Issue paper. Rome, FAO. Available at: http://www.fao.org/docrep/014/i2454e/i2454e00.pdf (accessed 11.02.2015).

Furukawa D. (2008) A Global Perspective of Low Pressure Membranes. Final project report. National Water Research Institute.

Guerra K., Pellegrino J. (2012) Investigation of Low-Pressure Membrane Performance, Cleaning, and Economics Using a Techno-Economic Modeling Approach. Science and Technology Program Report No. 174. US Department of Interior.

Hoekstra A.Y. (2002) Virtual water: an introduction. In: Hoekstra A.Y. (ed.) Virtual water trade. Proceedings of the international expert meeting on virtual water trade. IHE Delft, 12-13 December 2002.

Hutton G, Haller L (2004) Evaluation of the costs and benefits of water and sanitation improvements at the global level. Geneva, World Health Organization.

IRC International Water and Sanitation Center (2011) Scanning the 2020 Horizon. An analysis of trends and scenarios in the water, sanitation and hygiene sector. Occasional paper series 45., the Hague.

Mandri-Perrott C., Striggers D. (2013) Public Private Partnerships in the Water Sector. Innovation and Financial Sustainability. London.

Mekonnen M.M., Hoekstra A.Y. (2011) National Water footprint accounts: the green, blue and grey water footprint of production and consumption. Value of Water research report series No. 50. UNESCO – IHE Institute for Water Education.

Nickson A., Vargas C. (2009) The Limitations of Water Regulation: The Failure of the Cochabamba Concession in Bolivia. Bulletin of Latin American Research, Volume 21, Issue 1, pp. 99–120.

OECD (2010) Pricing Water Resources and Water and Sanitation Services.

OECD (2012a) OECD Environmental Outlook to 2050. The consequences of Inaction.

OECD (2012b) World Energy Outlook 2012.

Olivera O., Lewis T. (2004) Cochamabma! Water war in Bolivia.

Peek K. (2014) Where will the World's water conflicts erupt (infographic). A heatmap of war over water. Popular Science, June 13, 2014. Available at: http://www.popsci.com/article/science/where-will-worlds-water-conflicts-erupt-infographic (accessed 17.03.2015).

Prüss-Üstün A, Bos R, Gore F, Bartram J. (2008) Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. Geneva, World Health Organization.

Russian Federal State Statistics Service (2013) Statistical Reporting Form no. 22 "Housing", 2005-2013.

Saritas, O., Smith, J. (2011). The Big Picture – trends, drivers, wild cards, discontinuities and weak signals, Futures, vol. 43, issue 3, pp. 292-312.

Sklarew D. (2015) Presentation at the roundtable "Water Sector Scenarios", Moscow, 6 March 2015.

Soncini-Sessa R., Castelletti A., Weber E. (2007) Integrated and participatory Water Resources Management Theory. Elesevier.

Spronk S.J. (2007) The politics of Third World water privatization: Neoliberal reform and popular resistance in Cochabamba and El Alto, Bolivia, PhD paper.

United Nations (2010) Resolution A/RES/64/292. United Nations General Assembly, July 2010, Available at: http://www.un.org/waterforlifedecade/human_right_to_water.shtml (accessed 17.03.2015).

United Nations (2013) UN Water Scarcity factsheet, 17.05.2013. Available at: http://www.unwater.org/publications/publications-detail/en/c/204294/ (accessed 15.02.2015).

United Nations (2013a) UN-Water factsheet on transboundary waters. Available at: http://www.un.org/waterforlifedecade/transboundary_waters.shtml (accessed 15.02.2015).

UNESCO (2012) Managing water under Uncertainty and Risk. The United Nations World Water Development Report 4, Volume 1.

UNESCO (2012a) Knowledge base. The United Nations World Water Development Report 4. Vol. 2.

UNESCO (2014) Water and Energy: The United Nations World Water Development Report 2014, Paris. Available at: http://unesdoc.unesco.org/images/0022/002257/225741e.pdf (accessed 11.02.2015).

UNESCO (2014a) Water and Industry. Available at: http://webworld.unesco.org/water/wwap/facts_figures/water_industry.shtml (accessed 13.02.2015).

Wada, Y., van Beek L. P. H., Bierkens M/ F. P. (2012) Non-sustainable groundwater sustaining irrigation: A global assessment. Water Resources Research.

World Economic Forum (2005) Development-Driven Public-Private Partnerships in Water. Emerging Priorities from Roundtable Discussions. World Economic Forum, 2005. Available at: http://www.weforum.org/pdf/ppp_water_summary.pdf (accessed 17.03.2015).

Gleick P.H., Allen L., Christian-Smith J., Cohen M.J., Cooley H., Heberger M., Morrison J., Palaniappan M., Schulte P. (2011) The World's Water Volume 7: The Biennial Report on Freshwater Resources Paperback.

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