European Commission

Urban Water ATLAS for Europe

Joint Research Centre

Urban Water ATLAS for Europe

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The cover features the winners of the BLUECITIES painting competition (p. 142)

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Artworks and artistic editor:
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Faces of Water

Natalia Głowacka 2016
Prievidza, Slovak Republic
Mixed techniques, 50 cm x 50 cm

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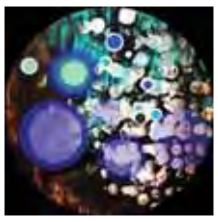

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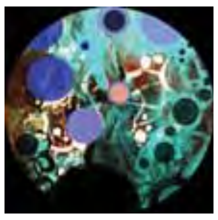

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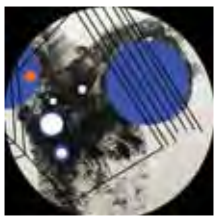

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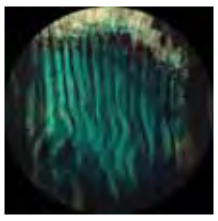

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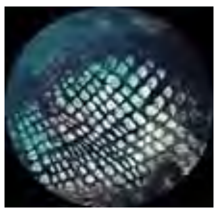

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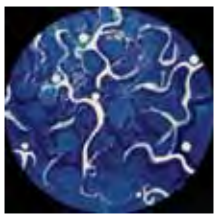

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This publication could not have been completed without the contributions of many talented scientists, water professionals, and photographers. Each photograph is labelled and acknowledges the photographer and contributor.
We thank all the children, pupils and teachers who participated in the painting competitions. Their enthusiasm formed the basis of our motivation to transform the Atlas from an idea to a physical reality.
We gratefully acknowledge the support and assistance provided by the Regional Development Agency of Dubrovnik Neretva County (DUNEA) for the organisation of the Dubrovnik Workshop, the support and availability provided the Environmental Institute (Kos, Slovak Republic) and the accurate last-minute language checks carried out by Ms Gráinne Mulhern (EC JRC) .
Special thanks are due to the Municipality of Greater Amman and the Association of Jordan SMEs who, as forerunners, accepted to transform their signing of the Dubrovnik Declaration of Intent into concrete actions.

Finally, we thank all our colleagues and supporters who responded positively to the endless small favours asked of them over the past two years.

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Contributor **Profile**

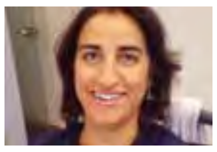
Lina AL-DASOUQIE

Jordan Small & Medium
Enterprises Association
Amman, Jordan

A qualified economist, Lina Al-Dasouqie is the CEO of Jordan SMEs, an industrial association which was established in 2008 in Jordan in order to support SMEs in achieving a better position in the market, whilst working rigorously to improve their competitiveness.
For those in Jordan, one of the most water-scarce countries in one of the most complex geo-political areas in the world, the intrinsic link between water and its mere existence is present everyday. Investments in water infrastructure, the sustainable management of water and collaboration with stakeholders is hence a leitmotif of Lina's career.

Water is so much more than a mere economic resource and too vital to be taken for granted.

Laura ALCALDE SANZ



European Commission
Joint Research Centre
Ispra, Italy

Laura's education (Ph.D. and M.Sc.) and work experience have been directed toward a sustainable management of water resources, focusing on reclaimed water use and the health and environmental risks associated with reuse systems. During her career, she has been involved in several international research projects that giving her the opportunity to work in different regions of the world such as the Mediterranean area, the Middle East, Latin America, and North Africa with the main aim of evaluating water resources management, especially wastewater treatment and reuse systems in urban and rural areas with conventional and non-conventional technologies. This fact allowed her to develop experience in the relationships between natural resources, technological innovations and the environmental and socio-economical aspects. Nowadays, she is working at the EC-JRC on the development of a potential regulatory instrument at EU level on water reuse. She is also involved in the European Innovation Partnership on Water.

Urban water management requires an holistic approach that considers all potential water resources.

Lorenzo ALFIERI

European Commission
Joint Research Centre
Ispra, Italy

Lorenzo Alfieri has a background in Civil Engineering and a PhD in Hydraulic Engineering from the Polytechnic University of Turin, Italy. He has more than 8 years' post doctoral research experience in international organisation, including the ITHACA Research Centre in Torin, a partner of the World Food Program, at the European Centre for Medium-Range Weather Forecasts (ECMWF) in the United Kingdom, and at the Joint Research Centre (JRC) of the European Commission, in Ispra (Italy). His research interests include large-scale flood hazard mapping, streamflow forecasting, flood early warning and flood impact assessment in the present and future climate. Since 2014, he works at the JRC, focusing on flood risk assessment at European and global scale under future climate projections. Lorenzo has co-authored 28 articles in peer-review scientific journals and is referee for a number of international scientific journals.

Cities of tomorrow will need smart solutions to adapt to the changing climate

Mona ARNOLD

VTT Technical Research Centre of
Finland Ltd
Helsinki, Finland

Mona Arnold (Lic. Tech., MBA) acts currently as a Business Developing Manager at VTT. She has over 20 years of professional experience and project management in a multitude of environmental processes, lately focussing on water management and circular economy, recovery and valorisation of resources. She is also a steering group member of the European Innovation Partnership (EIP) for Water and VTT representative in the European Technology Platform WssTP.

Smart means holistic and long-sighted. Sustainable growth can take place only if the cities enhance systems for saving and recycling their water resources.

Paulo BARBOSA

European Commission
Joint Research Centre
Ispra, Italy

Paulo Barbosa has a PhD in Forest Engineering and has worked for more than 25 years in the area of environmental sustainability and natural hazards. He has developed remote sensing applications in the areas of agriculture, forestry, land cover classification, and in the development of early warning systems for forest fires and droughts. More recently he has focused on the topic of climate change adaptation and its link to disaster risk reduction.

Droughts affect not only agricultural activities in rural areas but can have also a strong impact on cities where people largely depend on water reservoirs for their daily lives.

Nicola BAZZURRO

IREN SpA –Internationalization and
Innovation Department
Genoa, Italy

With an hydraulic Engineering degree from University of Genoa (Italy), Nicola Bazzurro has in-depth experience of the water industry sector. He was formerly Head of the Business Unit for Monitoring and Environmental Research, Manager of European projects in the water and environmental monitoring sector, and Secretary General of Fondazione AMGA. He coordinated activities of the Water Supply and Sanitation Technology Platform, publishing reports for the European Commission about research needs and priorities on Asset Management. Since June 2010 lead the Pilot Programme PP2 on urban areas, coordinating the work activity of several working groups such as managing rain events and flooding in urban areas, asset management for sustainable urban water, alternative water resources, sustainable sludge management in urban areas, monitoring and sensors, water treatment and pollution control. Since January 2015 he works with IREN SpA in the internationalisation and Innovation Department, where he is involved in scouting for technologies that would improve the efficiency of IREN's business companies.

Cities of tomorrow will be shaped by the way in which we use water.

Alexandre BREDIMAS

Strane Innovation S.A.S.
Paris, France

Alexandre Bredimas is the CEO of the French startup factory Strane Innovation. He is involved in several startup projects in the fields of energy, water, industry and smart systems. Before founding Strane, he worked at the at German energy utility E.ON in strategy and lobbying, the French nuclear vendor Areva as cost estimator and in the Paris-based consultancy LGI as BU Leader for Strategy Consulting. Alexandre holds three MScs in Systems Engineering, Financial Engineering and Technology Policy, and is fluent in French, English, German and Greek.

Cities are regional hubs that are physically linked by water to their surrounding natural environment: Let's use water as a political vector to structure the development of territories.

Gustavo CAPANNELLI

Innovative Technologies for Environmental
Control and Sustainable Development
(Ticass) scrl
Genoa, Italy

Gustavo Capannelli is the President of Ticass and Associate Professor of Industrial Chemistry at the University of Genoa. His research activity is mainly dedicated to the preparation and characterisation of membranes and membrane processes for various applications. He has managed various national and European research projects as well as several research contracts with national and foreign industries.

Water is a smart resource shaping the future of our cities

PAUL CHAPMAN

London Borough of Lewisham
Lewisham, London, U.K.

Paul is a Local Government officer based in south east London, specialising in European projects and partnerships. Using EU funding, he has overseen the reintegration of urban rivers through quality restoration projects resulting in the upgrading of local strategic plans and the development of new river-focused planning policies.
This approach has put Lewisham at the fore of the debate on urban rivers in the UK where Paul is a member of the national Urban Working Group. In addition, the policy work has been highlighted as good practice in the Greater London Authorities Green Infrastructure plan. Transnationally Paul is the Communications Officer for EIP Water's Smart Rivers Action Group and was the Project Coordinator for the ERCIP and QUERCUS projects, which focused on the multiple impacts of river restoration and development in urban areas.

Accessible urban rivers connect people to the source of their water use.

Hubert CHASSAIGNE

European Commission
Joint Research Centre
Ispra, Italy

Hubert Chassaigne graduated in chemistry from the University of Bordeaux (France). He was a Research Scientist at the French National Council for Scientific Research (CNRS), to obtain his Ph.D. in biochemistry in 1999. The defence of his Ph.D. was followed by a post doctoral stay in the UK (Rowett Research Institute, Aberdeen, Scotland). He was a Research Fellow of the Alexander von Humboldt Foundation (Bonn, Germany) at the Institute of Plant Biochemistry in Halle (Germany) and then a Research Fellow at the Joint Research Centre (JRC) of the European Commission (Geel, Belgium). Since 2012, he is a Scientific Project Leader and Laboratory Manager in the JRC in Italy. His areas of interests include food safety, chemical contaminants, health and environmental issues. Hubert Chassaigne is active in the field of modern analytical chemistry and applications, and publishes in international peer-reviewed scientific journals.

Big cities need smart strategies for water management, and smart chemistry for sustainable resources.

FREDERIC CLARENS BLANCO

Head of Industrial Ecology
Sustainability Unit
Fundació CTM Centre Tecnològic-Eurecat
Manresa, Spain

Frederic Clarens Blanco, born in Barcelona in 1974, has a Degree in Chemistry from the University of Barcelona (1998) and became a Doctor of Science at the Polytechnic University of Catalonia in 2004. Employed in 2005 as a researcher at the Fundació CTM Centre Tecnològic in the Environmental Technology Area, he is currently responsible for Industrial Ecology in the Sustainability Unit at Fundació CTM Centre Tecnològic-Eurecat, focusing on environmental assessment and waste management. During the period 2005-2007, Frederic carried out experimental work in the Joint Research Centre of the European Commision at the Institute of Transuranium in Karlsruhe, Germany.
He is co-author of 32 publications. His fields of expertise include the study of management and water treatment, the circular economy, waste management and life cycle assessment.

Smarter cities lead to the efficient use and the continuous improvement of their water and waste management processes.

SARA COMERO

European Commission
Joint Research Centre
Ispra, Italy

Sara Comero (1980) studied Physics and has a PhD in Earth Sciences from the University of Milan, Italy. She worked for the University of Milan and for a Regional Environmental Protection Agency in Italy, where she gained experience in atmospheric aerosol, mainly related to aerosols compositional dataset reduction and analysis. She joined the Joint Research Centre (JRC) of the European Commission in 2009 for three years, focusing on multivariate modelling techniques for the source identification of pollutants in environmental data. Back at the JRC in 2014, she works on chemical data management in the context of the development of an integrated data portal for emerging pollutants in European river basins.

Water is the full spectrum of colour in all its shades. A world without water is a black and white world.

AD DE ROO

European Commission
Joint Research Centre
Ispra, Italy

Ad de Roo works at the Joint Research Centre of the European Commission in Ispra (Italy) since 1997, currently as Project Leader for the "Water Energy Food Nexus 2030". He studied physical geography and obtained a PhD from the University of Utrecht in 1993. Since 2011, he is also a part-time professor of Physical Geography, especially Hazards and Impact" at the Department of Physical Geography Faculty of Geosciences, Utrecht University.
He works especially on projects where water issues are central, and particularly extreme events like floods and water scarcity. He has specialised in the field of large-scale modelling of water quantity, for which he developed the models and LISEM, LISFLOOD, and LISQUAL. He is co-author of the LISFLOOD-FP floodplain inundation model. He is the initiator of the European Flood Awareness System (EFAS) that issues operational flood forecasts to European authorities. He also is co-editor-in-chief of the scientific journal CATENA, and on the editorial board of the Journal of River Basin Management.

This initiative helps - I hope - to raise awareness that we should not take clean fresh water for granted. As long as it is available, many people take it for granted, but sooner or later more and more regions will face water access problems, unless we act now.

KEVIN DOUGLAS

European Commission
Joint Research Centre
Ispra, Italy

Originally from the UK, Kevin has worked all his life in scientific research from the analysis of water quality to crude oil and gas analysis, nuclear safety, renewable energy and, now, air quality analysis related to health and climate change. Outside of work he has a passion for nature and photography.

Water shapes our world and lives. It is a truly interdisciplinary field, where science meets politics and art.

PETER EASTON

Easton Consult SPRL
Brussels, Belgium

Peter Easton is a consultant in water management and stewardship, with 25 years' international experience across Europe, in the Middle East and Africa. Peter has an MSc in Hydrogeology from Birmingham University, UK, and a BSc in Geophysics from Newcastle-upon-Tyne University. He has experience in a wide range of sectors, including water supply, food and beverages, sustainable agriculture, wetland restoration and mining. The scope of his experience includes water supply investigation and development, regional water resources studies, computer modelling, environmental impact studies, corporate water risk assessment, water stewardship and 'plain language' communication on water through writing, presentations and training. Apart from consultancy, Peter has been employed by the Ministry of Water Resources of Oman and the Coca-Cola Company. Through Easton Consult, Peter is a consortium member of the Horizon 2020 project 'BlueSCities', which aims to promote sustainable urban water management.

Water is the most essential connection between all aspects of a healthy, clean, liveable and sustainable city.

RICHARD ELELMAN

NETWERC H2O/EURECAT-CTM
Manresa, Spain

Richard Elelman studied Politics in the UK before living in France, Spain, Portugal, the Middle East and India. He is currently Head of Public Administrations at EURECAT-CTM, and is the founder and Director General of the Network for Water in European Regions and Cities, NETWERC H2O. The former Deputy Mayor of Figueres, he is a political analyst who has, in recent years, specialised in Environmental and Scientific Policy and the links between Public Administrations, the world of Research and Development and Citizen Engagement. He has worked in collaboration with many supranational organisations as well as public authorities in numerous countries and is a regular speaker at international conferences in the United States, Europe and the Middle East on local authorities, water, energy, climate change and public political awareness. Richard was responsible for creating the first public electric bus line in Spain. A former member of the executive of Energy-Cities, he has received a number of awards including the CILMA Award for the Best Environmental Policy of 2009, the Medal of Excellence of the City of Saint Petersburg (Florida) and the Network@22 John Shields Award in 2011. He is the Coordinator of the Horizon 2020 project, BlueSCities and is a member of the EU Water Alliance and the Urban Intergroup of the European Parliament. He has recently been named as a member of the EIP Water Steering Group by European Commissioner Vella and is co-coordinator of the City Blueprints Action Group. In 2015 together with the JRC, he created the Dubrovnik Declaration of Intent and is currently finalising his methodology on Citizen Engagement in Sustainable Urban Strategies (ConCensus).

Water is, simultaneously, the greatest global challenge of the 21st Century and an opportunity to establish a new approach to diplomacy in which cities become the ambassadors of their respective cultures.

DAVID FELDMAN

Department of Planning, Policy and Design, University of California, Irvine
Irvine, United States

David L. Feldman is a Professor in the Department of Planning, Policy, and Design, and Political Science at the University of California, Irvine. Since 2014, Feldman has also served as Director of Water UCI - an initiative that facilitates seamless collaboration across schools, departments, and existing research centers around questions of fundamental and applied water science, technology, management, and policy. Water UCI engages in research, holds conferences and colloquia, offers courses, and undertakes community outreach in partnership with local agencies, schools, and others.
Feldman is author of Water Politics – Governing Our Most Precious Resource (Polity Books, 2017); The Water Sustainable City – Science, Policy, and Practice (Edward Elgar, 2017); Water (Polity Books, 2012); The Politics of Environmental Policy in Russia (with Ivan Blokov, Elgar Books, 2012); The Geopolitics of Natural Resources (Elgar, 2011), Water Policy for Sustainable Development (Johns Hopkins, 2007), and over 80 articles and book chapters.

Cities impose enormous pressures on freshwater supplies because they are often located some distance from the water sources needed by their populations. This compels them to build infrastructure to divert water from increasingly distant outlying rural areas, thus disrupting their social fabric and their environment. In addition, increasing urbanisation due to population growth, economic change, and sprawl place huge burdens upon the institutions, as well as the infrastructure, that deliver and treat urban water.

BERND MANFRED GAWLIK

European Commission
Joint Research Centre
Ispra, Italy

Dr Bernd Manfred Gawlik is a Project Manager at the European Commission's science and knowledge service, the Joint Research Centre. A qualified Chemist and Chemical Engineer by formation, he worked first in the field of chemical metrology.
In the past decade, he supported the implementation of all major European environmental directives involving chemical monitoring, with a special focus on water, waste and soil.
Currently, the focus of his work is on water reuse and recycling as well as novel approaches for Urban Water Management, with an emphasis on promoting innovation for more resilient mid-sized cities and municipalities.

Water is a truly interdisciplinary field beyond classical schemes, where science meets politics and art.

Stefano GIANAZZI

Innovative Technologies for Environmental Control and Sustainable Development (Ticass) scrl

Genoa, Italy

Stefano Gianazzi's prowess for cross-border initiatives built from scratch focuses on ICT and related R&D, Process Intelligence and Technology Transfer activities in the "Ecosystems" of Transport and Logistics, Energy, and Environment. Since joining Ticass, he has been involved specifically in EC-founded initiatives focused on waste and water, extending his expertise and contributing on topics such as data processing, architectures and systems interoperability.

Water is formless. It flows and roams wherever it wishes to go.

Natalia GŁOWACKA

Natalia GlowackArt

Częstochowa, Poland

Environmental Institute

Kos, Slovak Republic

Natalia Głowacka, M.Sc., M.A., is an up-and-coming Polish artist who graduated from the renowed Faculty of Art Education at Jan Długosz University (Częstochowa, Poland). She also holds a Master's degree in Biotechnology, with a specialisation on microorganisms. Natalia is co-author of the Water SciArt Diplomacy Concept presented in the Atlas. As a first practical application, her work on the water cycle was exposed in Amman (Jordan) and the European Commission's Ispra site, the main location of the Joint Research Centre in Italy on the shores of Lake Maggiore. She is currently helping to channel this concept to other initiatives related to Water Diplomacy, while preparing her Ph.D. on aspects of the circular economy using algae for biogas production.

When I started to work with water, I understood: when sciences meet art, a wonder called peace is happening!

Cevza Melek KAZEZYILMAZ-ALHAN

Istanbul University

Istanbul, Turkey

Prof. Alhan received her B.Sc. Degree in both Civil Engineering and Physics in 1998 and a M.Sc. degree in Civil Engineering in 2000 from Boğaziçi University in Istanbul, Turkey. She completed her Ph.D. studies in 2005 in Civil & Environmental Engineering at Duke University in the USA. She has been a Faculty member of Istanbul University since 2006 and Department Head of Civil Eng. since 2016. Her research interests include hydrological and water quality modelling of streams, lakes and wetlands, urban water management, flood analysis, Low Impact Development Best Management Practices (LID BMP), ground water flow, contaminant transport and surface water/ground water interactions. Among her publications are 15 SCI journal papers, 3 international book chapters, and 15 conference proceeding papers. She has given many presentations as invited speaker and is a reviewer of 10 SCI journals. Her awards include "The Most Outstanding Student Paper Award" given by teh American Institute of Hydrology, the "Freeman Fellowship" given by the American Society of Civil Engineers (ASCE) and DAAD (Deutscher Akademischer Austauschdienst) and DCAMM (Danish Centre for Applied Mathematics and Mechanics) fellowships. She has been involved in many national/international projects both as principle investigator and researcher.

Clear water, clear life.

Stef KOOP

KWR Watercycle Research Institute

The Netherlands

Steven (Stef) Koop, MSc, is a researcher at KWR Watercycle Research Institute in the Netherlands. His expertise is in the analysis and evaluation of urban water management and water governance. He is doing a part-time Ph.D. at the University of Utrecht's Copernicus Institute of Sustainable Development. The title of his dissertation is 'Towards water-wise cities: Assessing urban water management performance and required governance capacity'. Stef is the co-developer of the City Blueprint method, an indicator analysis of the urban watercycle, which is already being applied in 50 cities in 27 countries. He has also developed an assessment method that identifies the most crucial aspects for developing governance capacity to tackle water and climate adaptation challenges within a city. He is involved in various EU projects, and is a member of the EIP Water (European Innovation Partnership on water) City Blueprints action committee: http://www.eip-water.eu/City_Blueprints

By 2030, we will experience a 40% freshwater shortage. So time is running out and we need to act now.

Joana LOBO VICENTE

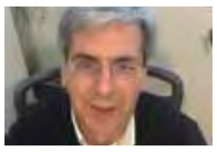
Joint Research Centre
European Commission

Ispra, Italy

Part of Joana's work is dedicated to the iDRIP Project, an exploratory research project, that aims to detect new psychoactive substances, classical drugs, pharmaceuticals, contaminants and pollutants in wastewater, drinking water and irrigation water.
She is currently a project officer at the Food & Feed Compliance. Previously, she worked in the Chemical Assessment & Testing Unit and the Molecular Biology & Genomics Unit of the JRC.
At the moment, she is involved in the proficiency testing of bisphenol A and the recycling of food contact materials into food contact raw materials.
Previously, she worked in the Scientific Action on New Drugs (SAND) project in collaboration with DG TAXUD and DG JUST, and in the Nanoproteomics project in collaboration with DG SANCO, ENV and RTD.

Cleaner water for a sustainable future.

Giovanni LOCORO



European Commission
Joint Research Centre

Ispra, Italy

Since 1990 Giovanni has worked as a technical assistant at the Joint Research Centre of the European Commission in Ispra (Italy). He has experience in the design and execution of soil campaigns, in analytical techniques for the evaluation of inorganic pollutants and in organic sample preparation for polar emerging compounds in environmental samples. Over the years, he collaborated on EU-wide monitoring campaigns, by planning and carrying out sampling campaigns and laboratory analyses as well as updating laboratory information system for data and laboratory equipment management.

Without sufficient water, there will be no economic growth in our cities. Cities of tomorrow will be shaped by how we use water.

Christos MAKROPOULOS

School of Civil Engineering,
National Technical University of Athens

Athens, Greece

Dr Christos Makropoulos is an Associate Professor in Hydroinformatics at the School of Civil Engineering of the National Technical University of Athens and the Chief Information Officer of KWR WaterCycle Research Institute in the Netherlands. He is a Visiting Fellow in the Centre for Water Systems of the University of Exeter, the co-Editor in Chief of the Urban Water Journal, and a member of the Editorial Board of the Journal of Hydroinformatics. Dr Makropoulos is an expert in hydroinformatic tools and methods for urban water management with an emphasis on distributed water infrastructure and whole city modelling. His work focuses on risk analysis, uncertainty quantification, multi-objective evolutionary optimisation, decision support and long-term policy scenario development. He has authored more than 100 journal and conference papers and book chapters, and is a reviewer for 15 academic journals. He is a Fellow of both the UK's Higher Education Academy and of the Royal Geographical Society. He is currently a Member of the joint IWA/IAHR Hydroinformatics Steering Group Management Committee.

Water services and water infrastructure are the very lifelines of cities, underpinning the quality of life that we take for granted. It's high time we re-thought their proper place in the agenda of the cities of the future.

Uri MARCHAIM

MIGAL – Galilee Research Institute

Kiryat-Shmona, Israel

Prof. Marchaim has an education in Biotechnology. He is involved in research on anaerobic digestion of organic wastes, in wastewater treatment, and in many ecological and waste utilisation projects, both in Israel and other countries He directs the European Wing of the MIGAL-Tel-Hai Research Authority, and is supporting scientists prepare proposals for the EU Programme, responsible for "matching" researchers and industries between the Galilee and Europe. He is the coordinator of the Water Cluster in the Galilee, and the Israeli coordinator of the EU projects SWAM, SCOW and WE@EU, which deal with water technology and wastes. These projects have an implementation approach and currently also involve cross-border issues.

Water is critical to all human activities. In Israel, we were suffering from water shortages and are very careful with its uses, especially for agriculture.

Giulio MARIANI

European Commission
Joint Research Centre

Ispra, Italy

Since 2014, Giulio has worked for the EU at the JRC Ispra, where he was involved in the following activities: Studies on the occurrence of POPs in different environmental compartments; Identification and measurement of priority substances to be included in the EU legislation; development of new approaches on water sampling and analytical methods and their application in order to support studies on efficiency and optimisation of technologies for pollutant removal and water recycling on EU scale; identification of new contaminants; reduction of the cost of water monitoring; and studying of new emerging compounds released to the environment by human activities (industrial, urban and agricultural), with a special emphasis on inland, coastal and marine waters.

The human right to drinking water is inextricably linked to the right to life and human dignity.

Xavier MARTINEZ LLADÓ

Sustainability Unit of Eurecat-CTM

Manresa, Spain

Xavier is a chemical Engineer with a Ph.D. in Science from the Polytechnical University in Catalonia. As a chemical engineer and environmental researcher, his professional objective is to transform scientific progress into practical applications with economic, social and environmental benefits. He is author of more than 15 scientific publications and supervisor of two Ph.D. thesis. As Head of Water Technologies with Eurecat-CTM, his current professional activity focuses on the design, execution and coordination of R+D+i projects in the field of chemistry, environmental chemistry and water treatment technologies. Specifically, he has broad experience in separation technologies such as membranes, ion exchange and phisico-chemical treatments.

The way in which we interact with water today will define the society of tomorrow

Ciprian NANU

Business Development Group
Bucharest, Romania

Ciprian Nanu is the founder of the Business Development Group (BDGroup), a Romanian owned management consultancy company with over 25 years' experience in multi-sectorial business development and local support on the Romanian and other Eastern European markets. The company was set up in the first project implemented in Romania by the Dutch Ministry of Economic Affairs (Programme for Co-operation with Emerging Markets, SENTER), and its business culture is based on the transfer of Western Europe knowledge, experience and entrepreneurship to Eastern Europe. BDGroup works with organisation worldwide with the primary purpose of safeguarding their (joint) ventures in Romanian business and political and social environment, based on a hands-on approach and using in-depth market knowledge and experience.

Water and cities in Eastern Europe are disconnected. Connecting them and their citizens might be top priority to improve future resilience.

Leonardo PICCINETTI

Rete Europea Dell'Innovazione
Rome, Italy

Leonardo Piccinetti is a Senior Research and Innovation Advisor, and the Brussels Director of REDINN Srl. He has broad experience in knowledge innovation transfer, operational outreach activities, and capacity building in EU urban, environment and water projects. Leonardo has a BSc in Economics from the University of Rome, with a special focus on water management in Mediterranean countries, an MA in European Studies from Sussex University and is a Ph.D candidate at Vilnius Gediminas Technical University, focusing on Innovation Economic. He is also a member of the EIP Acton Group City Blueprints, COWAMA and NETWERCH2O.

In general, water is our lifeline. It is, undoubtedly, the very essence of life.

Iva POZNIAK

Dubrovnik Neretva
Regional Development Agency DUNEA
Dubrovnik, Croatia

A Senior Associate for regional development and EU funds, Iva works on project preparation and coordination, specialising in projects on the environment, nature and coastal issues, sustainable development, management of marine and coastal zones, water management and ensuring compliance of Croatian legislation for environmental issues with EU legislation. She graduated from the University of Dubrovnik (2010) with a Master's degree in Mariculture / Aquaculture. She has, professional and scientific work experiences in marine biology and ecology, with a specialisation in the field of mariculture, and in the introduction of new marine species in commercial aquaculture production.

Water is a treasure that we take for granted, a cure for everything, tears for the heart, ocean for the soul, connecting all nations, where all life begins.

Peter SALAMON

European Commission,
Joint Research Centre
Ispra, Italy

Peter Salamon graduated with an M.Sc. in Applied Environmental Geoscience in 2001 from the Eberhard-Karls Universität in Tübingen (Germany). After working for two years with an international environmental consulting company in Frankfurt (Germany) as a Project Manager, in 2003 he started his doctorate studies at the Polytechnic University of Valencia (Spain), from which he received a Ph.D. in Hydraulic and Environmental Engineering in 2006. At the end of 2006, Peter joined the Joint Research Centre of the European Commission as a scientific project manager, where his main tasks are to provide policy support in the area of flood risk management at European and global levels. During his research activities and professional career, he has gained experience in hydrology, numerical modelling, flood risk and hazard mapping, assessing the effects of climate change on natural disasters, uncertainty estimation as well as operational flood forecasting systems. He has participated in numerous international research projects, and has published many peer-reviewed articles as author or co-author. Peter is now managing the operational European Flood Awareness System (EFAS) and the development of the Global Flood Awareness System (GloFAS), which are both part of the Copernicus Emergency Management Service.

The excess or scarcity of water will determine the fate of cities.

Ricardo RODRIGUES DA SILVA

Graphic Designer and Photographer
Lisbon, Portugal

Ricardo's Art education began at Antonio Arroio Art School in Lisbon at the age of sixteen. He later pursued a degree in Graphic Design from IADE-ESD in Lisbon while enrolling in several photography courses, with special interest in long-term documentary projects.

After working as a graphic designer in Lisbon, Ricardo moved to London to attend a Reportage Course at Central Saint Martins, and developed several projects within the city. Upon his return to Lisbon, he worked for Publico Newspaper and was later the recipient of the INOV-Art Grant, allowing him to work at NOOR photo agency in Amsterdam. Currently, he divide his time between working as an independent photographer and graphic designer, teaching and development of long-term documentary projects.

Water at its core, sustainability as its value. This is the city of the future.

Helle SKEJO

European Commission
Joint Research Centre
Ispra, Italy

Working as a Laboratory Technician at the JRC since 1990, Helle is presently responsible for sample processing and chemical analysis of a wide range of organic trace elements such as Dioxins, PCB's, PAHs, pesticides, flame-retardants and pharmaceuticals in water samples.

In 1982, she passed the abdf (chemistry, physics and biology) - Laboratory Technician exam at Teknisk Skole Frederikshavn in Denmark.

From 1982 to 1983, she worked at the Laboratory for Environment and Consumables (biological and chemical department) in Aalborg Denmark.

From 1983 to 1986, she worked on the US Airforce Base in Thule, Greenland as Laboratory Technician for Fuels Department. She was a laboratory half a year at the Energy Research Institute in Odense Denmark with Battery testing.

From 1987 to 1988 she was a QC supervisor at the US Airforce Base in Sondre Stromfjord, Greenland for Fuels Department.

No water – no buoyancy
No water – no spring
Water Earth's moiety
Summer will bring.

Anna STRZELECKA

De Montfort University
Leicester, U.K.

Anna Strzelecka received her Master's degree in Applied Mathematics from Lodz University of Technology in Poland in 2009 and her bachelor degree in Chemical and Process Engineering from the same university in 2011. In 2011 she started her Ph.D. research on sustainable households and communities in the Water Software Systems group at De Montfort University Leicester in the UK. Since 2015, she has been involved in the EU-funded project: BlueSCities and later POWER. She was responsible for developing the City Amberprint™– a set of indicators for assessing the sustainability of cities with respect to energy, transport and ICT. This framework was developed to complement the City Blueprint®. Additionally, she has been working with cities to identify best practices on water and waste management to share with other municipalities. Anna is also a member of the Barilla Center for Food and Nutrition (BCFN) Alumni Association.

We cannot have truly smart cities without realising that water, waste, food, energy, transport and ICT are all interconnected.

Simona TAVAZZI

European Commission
Joint Research Centre
Ispra, Italy

Simona Tavazzi is an EU official since 2011 at the JRC, Ispra, principally involved in the following activities:
assessment of the EU-wide occurrence of emerging chemical substances (e.g. pharmaceutical residues, food additives and novel chemicals) released by industrial, urban and agricultural activities to inland-, coastal- and marine waters; identification of priority substances to be included in the EU legislation, development of standardised methods for analysis of pollutants, as well as the optimisation of technologies for pollutant removal and recycling.
These activities are oriented towards:

- Supporting new technologies' development and application to identify specific opportunities and benefits of water reuse in each of the three main water sectors: agriculture, industry and urban sectors;
- Disseminating consistent data collections to all European Commission Services, agencies included.

Water-efficient technologies and water-efficient lifestyles play a crucial role across society.

Jutta THIELEN-DEL POZO

European Commission
Joint Research Centre
Ispra, Italy

Jutta Thielen-del Pozo is working for the European Commission since 2000 and is now leading the Scientific Development Unit. Her professional background is in atmospheric sciences which she studied at the University of Karlsruhe in Germany (1982-1989) and at the University of Lancaster in the UK, where she completed her Ph.D. (1990-1994). She has over 25 years' experience in interdisciplinary research related to the atmosphere, mostly in hydrometeorology but also in bio-meteorology, and the impact of severe weather on various sectors. From 2003 to 2012 she was responsible for the development of the European Flood Awareness System, one of the most successful flagships of the JRC in supporting policy DGs and the Member States with added value information related to flooding. She has also taken on leading roles in professional networks and partnerships, award committees, editorial and advisory boards.

Water is one of our most precious resources.

Nicola TUCCI

Independent Consultant

Pisa, Italy

Nicola Tucci is Senior Governance, Legal and Environmental Policy Advisor and is currently working in the public and private sector. He has more than 10 years' experience as a Project Manager with a specialization in EU environmental, governance and innovation-transfer projects. Since 2004, Nicola has been working with the University of Pisa and with several other research centers and companies as project manager in technology, innovation and knowledge transfer in environmental and energy areas, and is managing different FP7 and H2020 projects in water-, food- and energy-related fields in Europe and in MCP Countries (Palestine, Tunisia, Algeria and Libya). Nicola graduated in Political Sciences (2003), has a Masters of Arts degree in Political Governance (2007) and a Ph.D. in Geopolitics (2008).

The Water-Energy-Food Nexus is so much more than science and politics!

Bogumil ULANICKI

De Montfort University,
Faculty of Technology

Leicester, U.K.

Prof. Ulanicki graduated from the Warsaw University of Technology in Poland, and received Ph.D. and D.Sc. from the same institution. Since 1987, he has been working at De Montfort University in Leicester in the UK. Currently, he is Head of the Centre of Engineering Science and Advanced Systems (CESAS) and Director of the Water Software Systems (WSS) research group. His expertise covers the areas of control engineering, water engineering and ICT. He has over 135 publications in world-leading journals and refereed conference proceedings. Prof. Ulanicki has led 39 major projects (of which 20 were research projects) and 19 industrial projects for the UK and the EU water industry. His original contribution to the water engineering knowledge is in modelling, optimisation and control of water distribution systems.

Water is the blood of cities; without water, cities die.

Kees van LEEUWEN

KWR Watercycle Research Institute

Nieuwegein, the Netherlands

Cornelis Johannes (Kees) van Leeuwen, PhD is principal scientist at the KWR Watercycle Research Institute and Professor in Water Management and Urban Development at the University of Utrecht (UU) in the Netherlands. He studied biology (ecology and toxicology) and published more than 200 reports and publications and two editions of a book on Risk Assessment of Chemicals. He worked at the European Commission as Director at the Joint Research Centre (JRC) in Italy. From 1992-2007 he held a part-time professorship in Biological Toxicology (environmental risk assessment) at the UU. Between 1980 and 2001, he worked in three Dutch Ministries on water, chemicals, health and the environment. He has been member of various policy and expert groups in the International Rhine Committee, European Commission, OECD, UN, and the European chemical industry. Currently, he coordinates the City Blueprint Action Group of the European Commission: http://www.eip-water.eu/City_Blueprints.

Regular benchmarking, with e.g. the City Blueprint approach, based on SMART goals is needed to monitor progress of the transition process towards water-wise cities.

Ine VANDECASTEELE

European Commission
Joint Research Centre

Ispra, Italy

Ine Vandecasteele is a hydrogeologist with a broad experience ranging from hydrological modelling to GIS and analytical chemistry. Her previous work at the Royal Museum for Central Africa in Belgium focused on the mitigation of geomorphological hazards. She has been working at the JRC in Ispra since 2011 looking at both quantitative and qualitative aspects of water management in Europe. Projects she has been involved in include the analysis of sectoral water consumption, water retention in the landscape, the potential impacts of shale gas extraction on water resources, and most recently the monitoring of new psychoactive substances in wastewater.

We have the resources to resolve any current and future issues related to water – we just need to use them.

Davy VANHAM

European Commission
Joint Research Centres

Ispra, Italy

Born in 1974 in Belgium, Davy Vanham holds a M.Sc. in applied agricultural sciences from the University of Leuven (Belgium) and a M.Sc. in water resources engineering from the University of Brussels (Belgium). He obtained a Ph.D. from the University of Innsbruck (Austria) in integrated water resources management (IWRM).

Davy has more than 15 years' work experience in IWRM, both in the private sector (for engineering consultants) and the public sector (universities and the European Commission), during which he spent many years abroad. This includes several years of professional experience working in developing/transition countries.

Since 2011, he works as a researcher on IWRM in the EU, at the Joint Research Centre of the European Commission. His research focuses on the interdisciplinary management of water resources and its uses. His interest extends to the communication of science to policy as well as the general public.

Water is our most precious resource. We require it for our three basic securities: water, food and energy security.

Jürgen VOGT

European Commission
Joint Research Centre

Ispra, Italy

Jürgen Vogt joined the European Commission's Joint Research Centre (JRC) in Ispra, Italy in 1988. He obtained a Diploma in Rural Survey from ITC in Enschede, the Netherlands, and M.Sc. and Ph.D. degrees in Physical Geography, Climatology and Remote Sensing from Trier University, Germany. He chaired the International Working Group on GIS Aspects of the European Water Framework Directive and led the development of the CCM River and Catchment database for Europe. Since 2008, he has been team leader for drought and desertification at the JRC and is responsible for the development of the European Drought Observatory (EDO). More recently, he initiated the development of a Global Drought Observatory (GDO). Jürgen is involved in several research projects on the monitoring and forecasting of droughts and their impacts, and on the assessment of societal and environmental vulnerability to droughts in Europe and globally. He has published extensively in these fields, including the edition of a book on Drought and Drought Mitigation in Europe. He co-organised the UNCCD 1st Scientific Conference on 'Understanding Desertification and Land Degradation Trends to Support Decision Making in Land and Water Management', held in Buenos Aires, Argentina, in 2009.

Access to clean water in sufficient quantity is key to future development.

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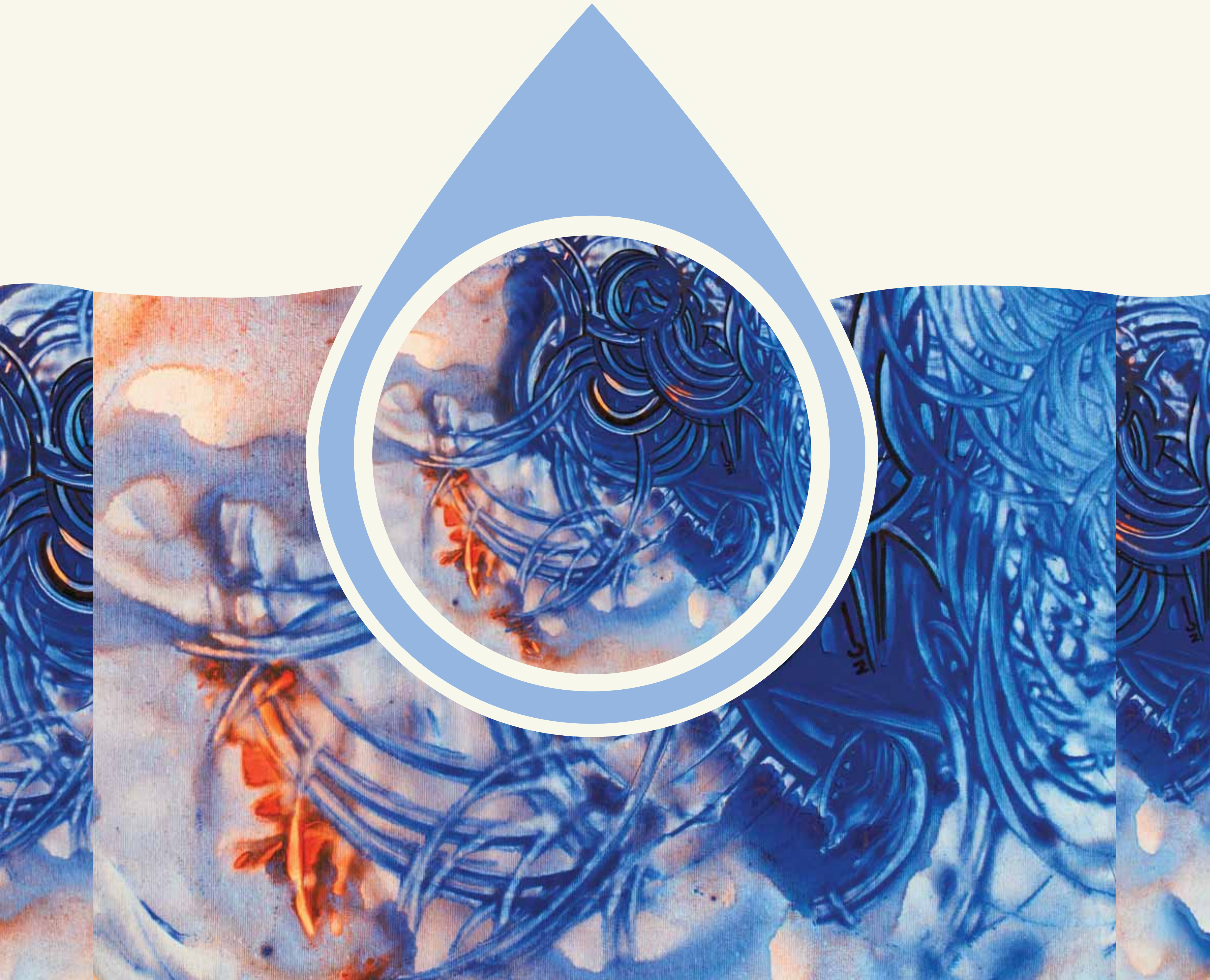

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Water globally
(Woda globalnie)
Natalia Głowacka, 2016
Częstochowa, Poland

80 x 80
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas

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INTRODUCTION

Key Messages

In order to ensure water-wise and resilient cities, which can address the risks resulting from climate change whilst maintaining a high level of urban life, cities should strive to:

. Understand and optimise the interaction between their water services and other critical infrastructures.

. Measure and critically assess their current performance whilst defining specific, measurable, achievable and realistic objectives within a precise timeline.

. Engage in true citizen engagement, employing a participatory and open approach.

. Promote green and blue economics at local and regional levels.

. Join forces with other cities in intercity collaboration, and embrace the principles of new forms of environmental science diplomacy at a local level.

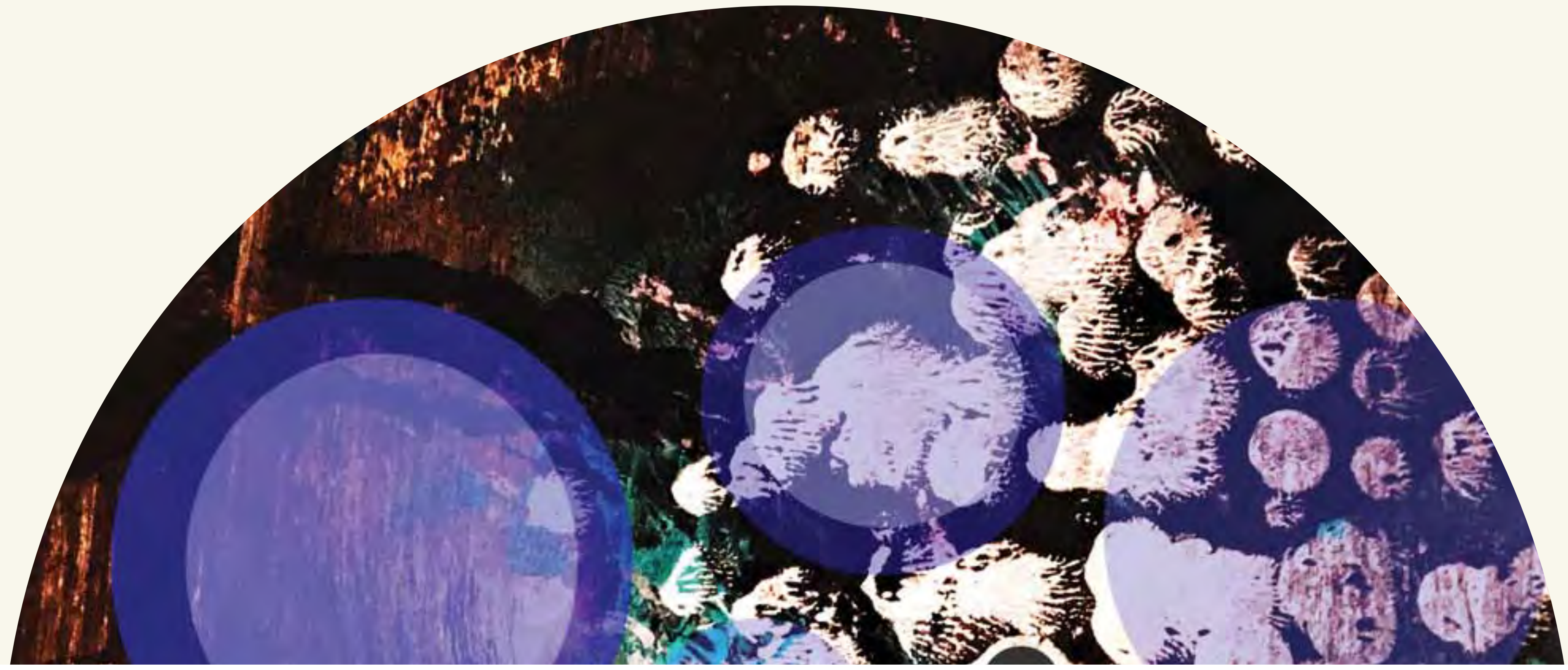
. Communicate and share, in a clear way, information concerning water management.

. Create a legacy and a true connection between generations, from the youngest to the oldest citizens.

Water power
(Moc wody)
Natalia Glowacka, 2016
Częstochowa, Poland

80 x 80
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas



Introductory Notes

Water is the source of life. Its global importance is beyond question. It is essential for all human settlements, including cities. Water influences our social, economic, political and cultural lives. Above all, it is a human right, as recognised by the United Nations back in 2010. The 2015 Sustainable Development Goal (SDG) of Clean Water and Sanitation aims to ensure access to water and sanitation for all, as part of an international effort to fight inequalities and tackle climate change.

In order to quench the growing thirst of our planet, we need to manage water intelligently, certainly more intelligently than we have done to date. Water is an irreplaceable resource for society, but it is only renewable if well managed. We need to be open to innovation with regard to water management, especially in our cities - the urban areas which are home to an ever-increasing majority of the world's population.

In order to foster innovation and achieve its acceptance by society, scientific and technological knowledge must not only be generated but also communicated in a way that can be understood by all citizens. What must follow is an open public debate in which the priorities of our political agendas are established. And what better way to facilitate such a debate than through art?

Through the passage of time, the role of water as the principal ingredient of life has been reflected in the world of art. It is the one element that has dominated human civilisation. Observing man's perception of water through the eyes of the artist allows us to appreciate a simple truth, too often forgotten, which is that we simply would not exist without water.

The Urban Water Atlas for Europe reveals the new, pioneering concept of Sci-Art Water Diplomacy. This concept first appeared in a pilot scheme in Jordan which led to the exhibition "Science and Art in Water – Water through the eyes of Jordanian children", organised under the auspices of the Jordanian Minister for Education by the European Commission's science and knowledge service (the Joint Research Centre) and the partners of the Horizon 2020 Project, BlueSCities. Schoolchildren from different countries were encouraged to consider the water problems facing their region and to describe their personal feelings through drawings. The children's thought-provoking, yet innocent images called on society to progress towards a more ecological, more sustainable and more peaceful future, perhaps far more effectively than any scientific treatise.

The dramatic results of this exercise laid the philosophical basis for the Urban Water Atlas for Europe. The Atlas gathers best practices of urban water management, and demonstrates how cities are addressing issues by endeavouring to become not only smart, but also resilient to the water challenges that lie ahead. The multi-sector collaboration involved in preparing the Atlas helped show local politicians the necessity for cities and towns to convert supra-national intentions into feasible regional and local realities with regard to water and climate resilience, whilst demonstrating the advantages of an inter-municipal partnership based on trust and experience.

The Atlas thus shows the way towards a new and even stronger European ideal. We hope it will be a source of inspiration for you all.

European Commission

ctm

KWR

netwerch2o

Message from Fundació CTM Centre Tecnològic

As the Director General of the Fundació CTM Centre Tecnològic, one of my principal policies in recent years has been the creation of bridges between the world of science, public administrations and the citizen. If, as a society, we are to successfully respond to the global environmental challenges which we face in this century, specialists of all relevant sectors must learn to join forces so as to prove capable of forming a holistic approach at a municipal level in order to guarantee the implementation of the necessary measures proposed in supranational forums. The resulting technological, economic, social and political strategies can and indeed, must lead to a more sustainable community for generations to come.

The Urban Atlas of Europe is a fine example of an initiative which has embraced the joint talents of scientists, researchers, political analysts, artists and children. Coordinated by the Joint Research Centre of the European Commission and the partners of the Horizon 2020 project BlueSCities it presents the issue of water, the most vital of all resources, in a format which I feel sure will be appreciated by both the informed expert and the interested layman, thus fulfilling a role which scientists have often ignored at their peril; that of popular communication. The reader of this comprehensive yet deliberately accessible text, will discover the intricacies of the Urban Water Cycle, the problems which confront those who are responsible for managing such systems and the realities of water distribution systems which most people tend to merely take for granted.

In my opinion, by illustrating the situation in 40 European cities and by clearly explaining the issues at stake, the Atlas also demonstrates that a new relationship between the supranational and national powers with their municipal and regional counterparts is not only desirable but imperative. This is something which the Fundació CTM has energetically advocated in recent times, most noticeably by creating in 2012, the Network for Water in European Regions and Cities (NETWERC H2O) whose principal aim is to ensure a permanent dialogue between international, national and municipal, elected stakeholders and the citizens who they represent. Furthermore, the Atlas demonstrates that cities cannot work alone as individual, autonomous units. They are obliged to interact not only with their urban areas and hinterlands but also with other cities, exchanging knowledge and experiences in a truly beneficial atmosphere of collaboration and mutual support.

This book constitutes an important source of information which must be transmitted to all people, young and old. The lessons it teaches points to the fact that everyone, no matter who they are, has a role to play in the creation and maintaining of a social consensus as well as the importance of the citizen's active participation in local actions regarding the future of water. Only in this manner can we claim, as a society, to be capable of ensuring the socio-economic support and political continuity required in the fight for a planet in which no one, no matter where they live, lacks the basic necessities of life.

Prof. José Manuel PRADO POZUELO
Director General of the
Fundació CTM Centre Tecnològic

Message from KWR Water Cycle Research Institute

The global water sector is entering a period of profound change as it pursues evidence-based responses to a host of emerging global, regional, national and local challenges. The World Economic Forum has identified the water crises as the top global risk for the next decade. Other risks that made this list are inextricably tied to water: failure of climate-change mitigation and adaptation, extreme weather events and the food crises.

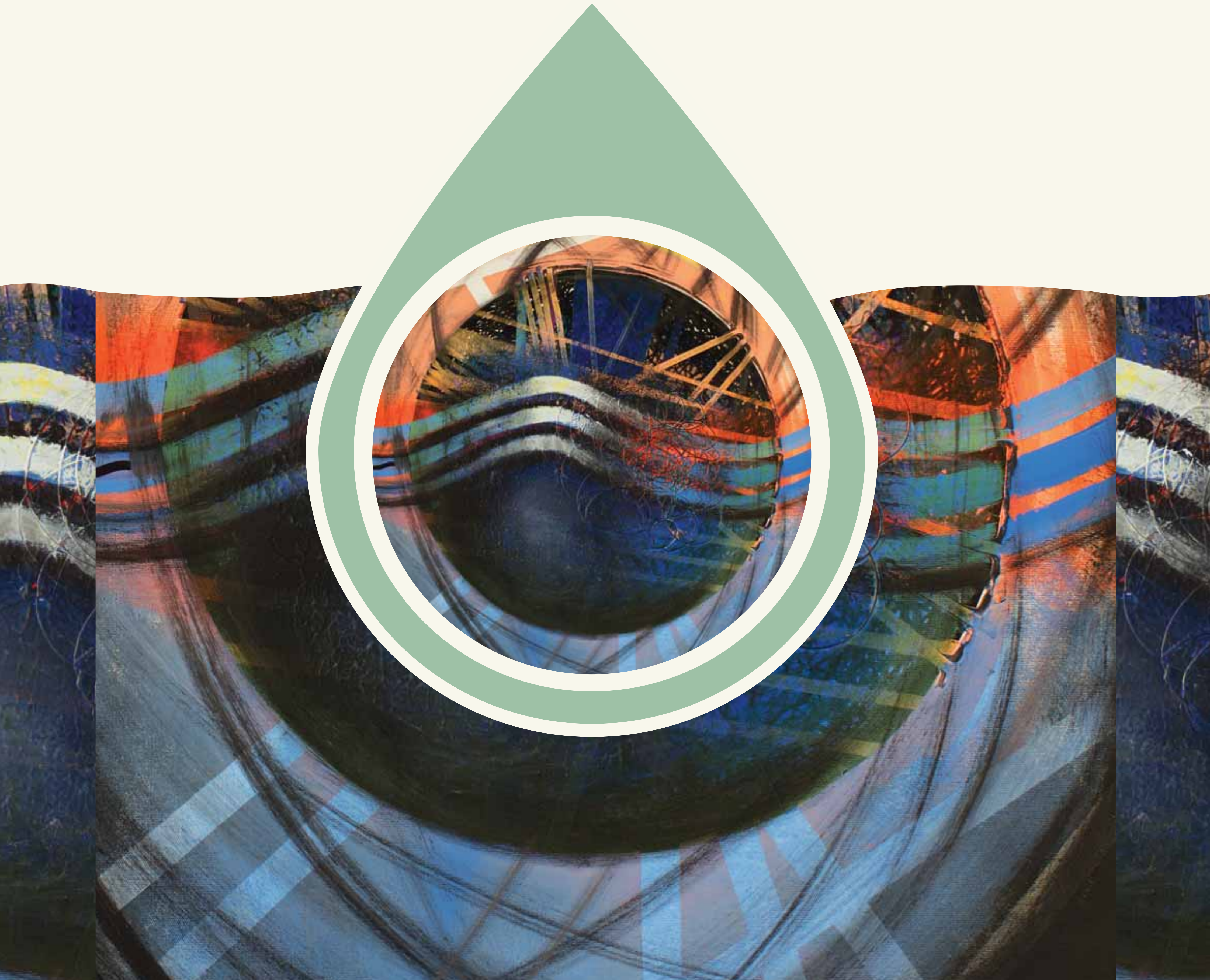
Worldwide, the supply of sufficient and clean freshwater is under pressure, a situation many see as a water governance crisis. A major effort is needed to improve the sustainable use of our freshwater resources: they surround us practically everywhere but face a multitude of risks and challenges. Aging infrastructure and urbanisation is leading to water pollution and to increased and sometimes unsustainable withdrawals of both surface water and groundwater. Changing precipitation patterns and evaporation, caused by the intensification of agricultural activities and climate change, are resulting in reduced groundwater recharge. Salinization is threatening the availability of fresh groundwater and surface water in coastal areas, where most of our cities are located. Groundwater quality too is threatened by human activities, both above ground and in the subsurface. In short, in pursuing the sustainable use of our freshwater resources, water companies and water managers are confronted with a number of pressing questions.

The Blueprint to Safeguard Europe's Water is the European Union's policy response to these challenges. It aims to ensure good quality water in sufficient quantities for all legitimate uses. Cities are concentrated centres of production, consumption and waste disposal. These activities drive land-use change and are the source of a host of global environmental problems. Cities are highly dependent on other cities and on their hinterlands for raw materials, water, energy and waste disposal. This Urban Water Atlas for Europe is intended to complement the EU's Blueprint, by providing extensive information on the current water situation in many European cities and highlighting the central importance of cities in achieving the policy objectives. In effect, the challenges of sustainable water-use will be met primarily in our urban centres, where most people live.

It is very gratifying to see that the City Blueprint, a tool of KWR Watercycle Research Institute, has been put to such effective use in this atlas by the Joint Research Centre. Over the past few years, working with our Watershare partners and the EIP Water City Blueprint Action Group, and many partner cities, we have succeeded in developing the City Blueprint Approach into the best tool for making baseline assessments for the sustainability of Urban Water Cycle Services of cities and regions. City Blueprint assessments have been made in nearly 60 cities in more than 30 countries. I hope and expect these numbers will increase in the near future as cities, in Europe and elsewhere, become increasingly water-wise.

Prof. Dr. Wim VAN VIERSSEN
Chief Executive Officer of
KWR Watercycle Research Institute

INTO THE CITY



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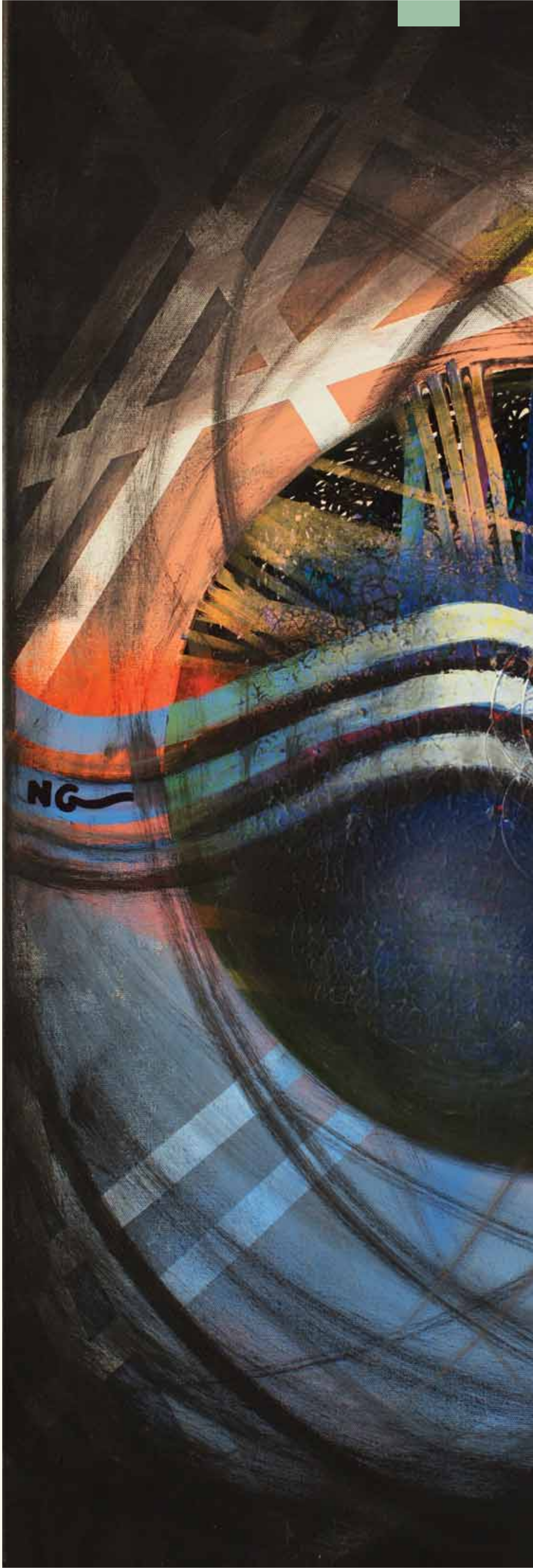
Water world
(Wodny Świat)
Natalia Głowacka, 2016
Częstochowa, Poland

100 x 70
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas



The Role of Cities
in the Modern World

Author(s) | ***Kees Cornelis Johannes VAN LEEUWEN***

Miami Florida city skyline morning with blue sky © digidreamgrafix / Shutterstock.com

More than 50% of the human population lives in cities

Today, there are more than 400 cities with more than a million inhabitants. Twenty-three cities have more than 10 million inhabitants, defined as megacities, most of which are in Asia (United Nation, 2012). More than 50% of the world's population now live in cities, expected to reach 67% by 2050 (United Nation, 2012). In developed countries, the current percentage is 86%. The speed of change is fast. In 1970, there were just two megacities, Tokyo and New York, increasing to 10 megacities in 1990, 23 in 2011, and 37 projected for 2025.

The growth in the number of megacities is in parallel with general population trends. The UN estimates that between 2011 and 2050, the world population will grow from 7.0 to 9.3 billion. In the same period, the total urban population will grow from 3.6 to 6.3 billion, while the population of rural areas will decline. Thus, the world population growth will be mostly absorbed by cities, with the urban population growing by 200 000 people, or one medium-sized city, per day!

Cities

Cities play a prominent role in economic activity and development, currently producing, collectively, more than 80% of the Gross World Product (GWP). Six hundred urban areas with just 20% of the world population generate 60% of the GWP (Dobbs et al., 2011). Cities are also centres of communication, innovation and creativity, and play a large part in social and cultural matters (European Commission, 2011; BAUM, 2013).

The global economy is changing as rapidly as the trend towards urbanisation. The transformation of China, through both urbanisation and industrialisation, is occurring 10 times faster than in the United Kingdom at the height of its 19th-century industrialisation (Dobbs et al., 2012).
This comparison is illustrated by an example from the chemical industry (Van Leeuwen, 2008). In 2001, chemical production was divided more or less equally between Europe, North America and the rest of the world. However, in the years since, the hub shifted to Asia which now has a more than 50% share (CEFIC, 2012). A McKinsey Global Institute report (Dobbs et al., 2012) predicts an acceleration in the shift of the economic hub to the 'new' developing countries, particularly Asia, which will again become the global economic epicentre after a five century gap.

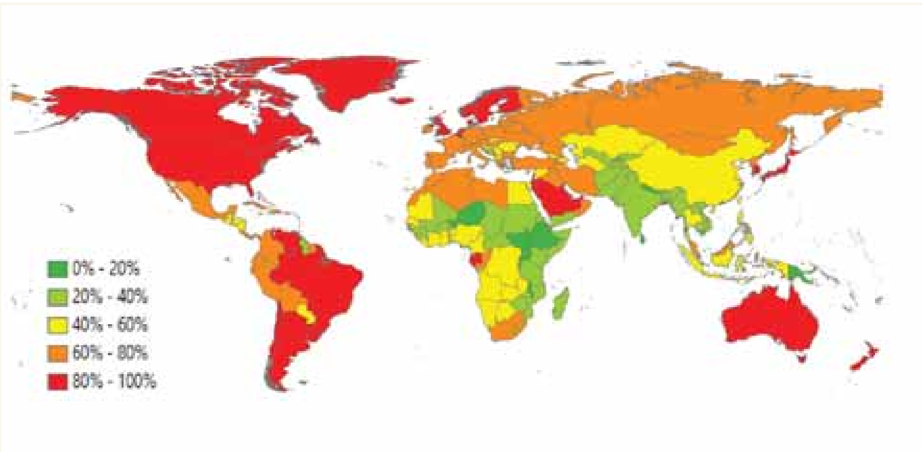


Figure 1: Growth rate of urban population (per cent). (Source: Akantamn, 2016a)

Cities as centres of consumption and generators of waste

Cities can take a lead in sustainable development, in part through economies of scale, using fewer resources per person (BAUM, 2013). However, the concentration of homes and employment also has its downside. Cities currently take up about 2% of the Earth's land surface, but account for 60-80% of energy consumption. About the same percentage also applies to the use of raw materials (e.g. metals, wood, plastics, etc.) for infrastructure, houses, cars and numerous other consumer items.

Cities are concentrated centres of production, consumption and waste (Grimm et al., 2008; Bai, 2007), sometimes exceeding their carrying capacity by a factor of 10-150 (Doughty and Hammond, 2004). This creates enormous pressure, not only on water supply and wastewater management, but also on the natural and built environments, significantly contributing to soil, air and water pollution.

Cities are, therefore, highly dependent on rural areas for resources, food and materials, and as the receives of their waste. This includes water supply. For example, the megacity of Istanbul (population 14 million) is supplied with water from sources as much as 180 km away. Consequently, the city must ensure that distant basins supplying its water sources are maintained.

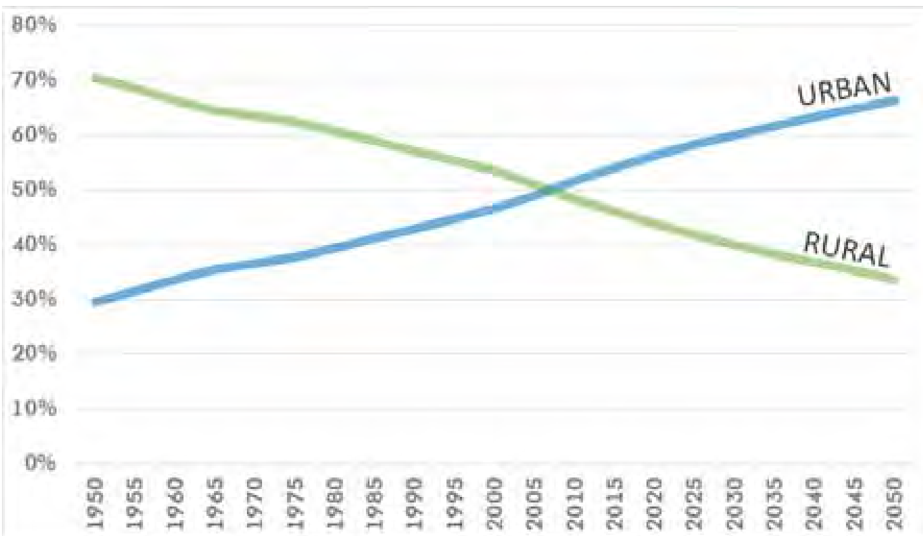


Figure 2: The world's urban and rural population, 1950-2050. (Source: Akantamn, 2016b)

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Understanding the Urban Water Cycle

Author(s) | ***Peter EASTON***

Closeup photo of woman washing hands in a city fountain © Maria Sbytova / Shutterstock.com

The water cycle in a city

Water is an integral part of many aspects of city life, but it is often not appreciated how these different aspects are connected and mutually reliant. Just like the natural water cycle, there is an urban water cycle, which itself is linked to the natural cycle. A city and its inhabitants need to recognise that they borrow water from the natural cycle, to which it must return. Water is a sustainable, non-finite resource provided it is not overused, and is returned to the natural cycle in a clean condition, to continue in that cycle, to be re-used by the city, others or the natural environment.

The main steps in the urban water cycle are: abstraction from the environment; treatment to drinking water quality; storage and distribution; use; discharge to the wastewater network; treatment or cleaning of wastewater; and, finally, discharge back into the natural environment. Some water may also be re-used or recycled within the city.

Where is water used in a city?

The main uses of water in a city are for domestic use, in households, public buildings and offices (about 75%), and for industry (about 25%). Water is used for drinking, food preparation, cleaning, heating, cooling, irrigation (mainly domestic gardens and public green areas) and industrial processes. In many cities, water forms natural features such as rivers, lakes and coastal areas, commonly used for leisure, and may also be used for transport. Large water bodies often contribute to the well-being of a city, and help define its fundamental character – such as the Seine in Paris, the Thames in London and the harbour in Sydney. Some cities include limited areas of agriculture within their boundaries, which may require a water supply.

The historical links to water

Most cities were established in locations with a good accessible water supply. Rivers have been the most popular water body as they provide both a water supply, and a means to carry wastewater away. Water bodies have also provided other benefits to cities as acting as a a defence barrier and for transport of people and goods. Alternative water bodies include canals and lakes. For coastal cities, the sea also provides most of those benefits, other than for a drinking water supply, except via desalinisation, which remains costly and relatively rare. Thus, many cities have a long and intimate link with water with, for many, a principal river being forever associated with a city's personality.

Figure 3: Old London Bridge in year 1710

Water and transport

Historically, water has always been important for transporting goods into and out of cities. Its role in public transport, in addition to celebrated examples such as Venice, and for tourism, has growing importance in cities that are moving towards more sustainable transport networks, with ferries, river buses and river taxis.

Image 1: Dhaka steamers (Bangladesh).
(Source: de Leeuw, 2006)

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Where does water come from?

Water sources

Historically, the most common source of water was surface water from rivers, streams or lakes. Springs and hand-dug wells were also used, but rarely had sufficient capacity to support rapidly growing populations.

As cities grow, or if local supplies become too polluted, it is necessary to extend to water sources further away, sometimes transporting water great distances via canals and aqueducts (as in Roman times), or pipelines. Commonly, rivers have been dammed to create large storage reservoirs to smooth out the effects of varying river flows and rates of water use. During the past century, drilling and pumping technologies have enabled cities to access deeper aquifers which are,, in effect, large natural underground reservoirs.

Today, most water supplies are from fresh surface water or groundwater, with a fairly even split across the world. The choice is dependent on local conditions, geology, economics and tradition. Modern water source alternatives include desalinised seawater or brackish water, and recycled wastewater (after treatment and for specific uses). A city will normally have a number of water sources, and often a mix of types.

Figures show the case of Lyon

(1) Water abstraction from groundwater
(2) Production of drinking water (ca 100 Mio m^3 per year)
a. Precipitation of ca 450 Mio m^3 per year.
(3) Storage in a water reservoir
(4) Distribution to
a. Individual households
b. Industries
(5) Water sanitation system
a. Separated rainwater collection system
b. Combined network collecting 180 Mio m^3 per year
c. Stormwater overflow (ca 13 Mio m^3 per year)
(6) Wastewater treatment plant
(7) Release to the natural environment

From source to tap

Raw water is abstracted, normally by pumping, from its source: a surface water body or water well (also called a borehole). It passes through a water treatment process and is then distributed to all points of use via a pipeline network. Storage reservoirs (before or after treatment) provide a buffer in the system to smooth out varying rates of water use, or temporary physical failures in the system.

The system needs pressure to get water to all points of use, which can sometimes be along kilometres of pipe. Pressure is provided by pumps and, where possible, by gravity, for example through the use of water towers. Pressure must be carefully controlled and monitored to avoid too high pressure which increases leakage rates and can burst weak and old pipes. If pressure is too low, water does not get to all consumers and pollution can more easily enter pipes and contaminate drinking water.

Figure 4: The urban water cycle. (Artwork by Natalia Głowacka 2016, Prievidza, Slovak Republic)

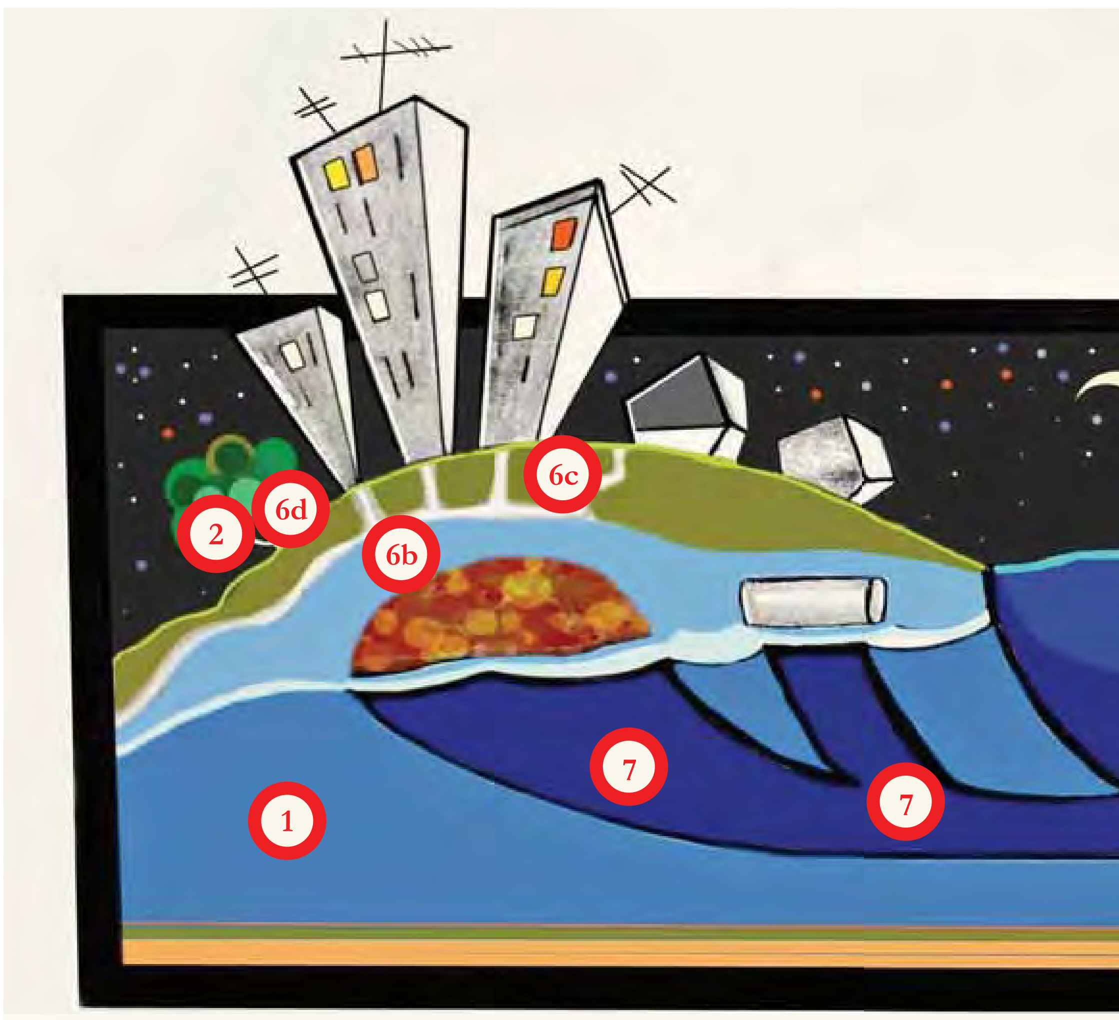
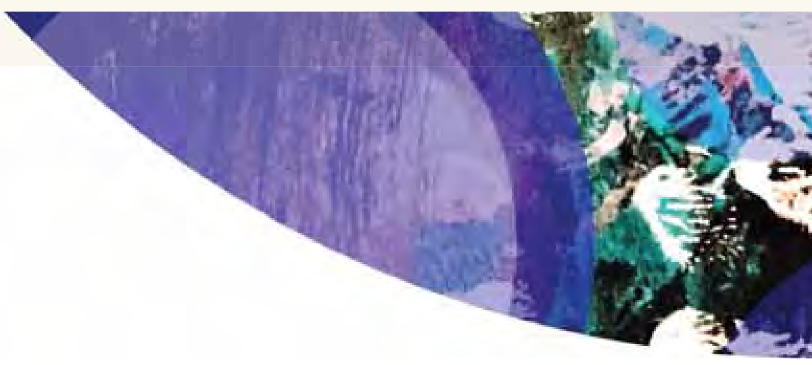


Figure 5: Water abstraction and the groundwater flows. (Artwork by Natalia Głowacka 2016, Prievidza, Slovak Republic)



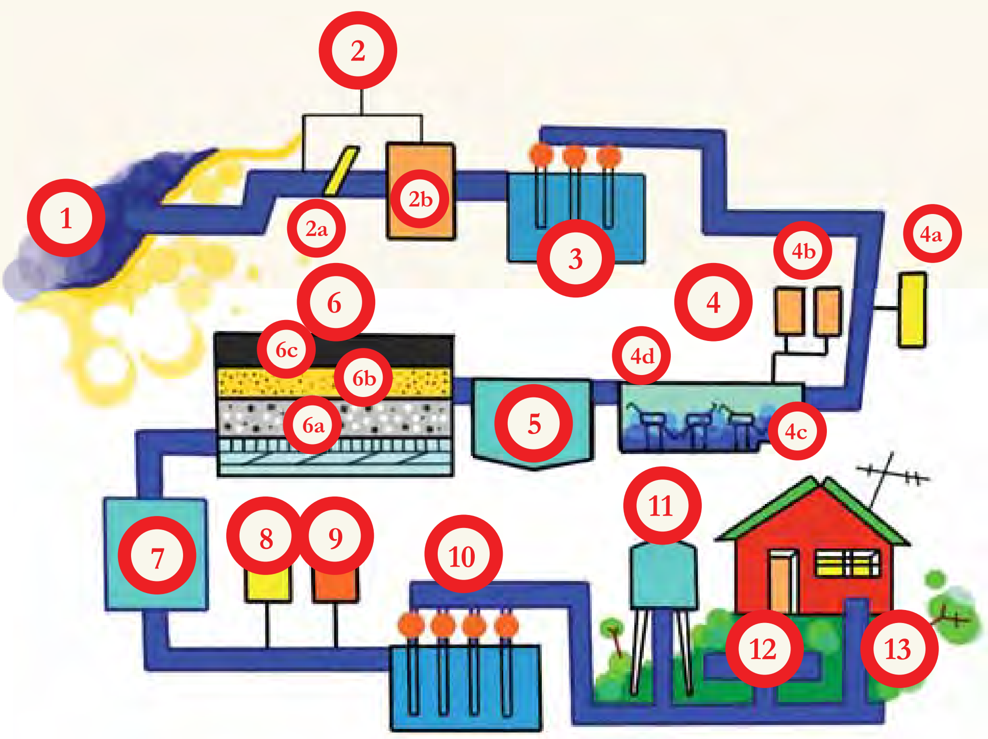


Figure 6: Drinking water. (Artwork by Natalia Głowacka, 2016, Prievidza, Slovak Republic)

Drinking Water

(1) Intake pipe at a lake or river
(2) Preliminary treatment
a. Protective bar screen
b. Travelling water screen
(3) Low-lift pump well
(4) Fine particle removal
a. Pre-chlorination
b. Chemical coagulants
c. Coagulation
d. Flocculation
(5) Sedimentation basin
(6) Sand filtration
a. Gravel
b. Sand
c. Anthracite
(7) Clear well
(8) Post-chlorination
(9) Fluorination
(10) High-lift pump well
(11) Elevated water storage tower
(12) Ground-level reservoir
(13) Distribution system

Water abstraction and the groundwater flows

(1) Saturated zone
(2) Unsaturated zone
(3) Impermeable layer
(4) Boreholes
a. From public water supply service
b. From private users
(5) Surface water (river, lake, or artificial reservoir)
(6) Groundwater threats and risks (examples)
a. Septic tank
b. Landfill or mining waste
c. Sewer pipes
d. Diffuse pollution, for instance from agriculture
(7) Groundwater flows
(8) Drinking water production site

Water treatment

Why do we need to treat water?

Most cities have a single distribution network, so the aim is to ensure that all distributed water is safe to drink at the point of use, even though most uses are not for drinking. Some cities have a dual system, where poorer quality, 'grey', water is separated for less sensitive uses, but this is quite rare. There are two main reasons for treatment. First, to make raw water safe, which is essential for all surface water sources, but not for many groundwater sources (including springs), which are often safe at source due to the natural filtering properties of soil and rocks. Second, water is treated to protect its quality and safety in the distribution system, where it is vulnerable to pollution, mainly microbiological, from open air in storage tanks, damaged pipes and the potential for build-up of pollutants and biofilms in lengthy pipework.

Comprehensive water treatment is a relatively new development in human history. The link between drinking water and waterborne diseases (such as cholera) was only discovered in the late 1800s. Microbiological contamination remains the main risk, but metals, organics and pesticides may also need to be removed.

How is water treated for public supply

The most common water treatment process is a multi-barrier concept: coarse filtration (to remove any large debris): coagulation and flocculation (adding special chemicals to coalesce and settle fine suspended particles, which may discolour the water and carry pollutants); sand filtration (to remove remaining fine particles); activated carbon filtration (to remove organics and pesticides); chlorination (to kill microbes and maintain a residual disinfection effect throughout the distribution network).

Alternative, or additional, barriers include membranes (very fine synthetic filters); softening filters (to reduce calcium-magnesium hardness); and UV (ultraviolet light as an alternative disinfection method).

A well designed water treatment process can handle all relevant types of pollution. However, a more sustainable approach is to put more emphasis on protecting the raw water source and its catchment so as to reduce the amount of treatment required. This 'water safety plan' approach is more sustainable as it requires less energy and chemicals for treatment and also helps protect the natural environment and its biodiversity.

Understanding the Urban Water Cycle

Wastewater

Types of wastewater

One of the most important ways to ensure a sustainable water cycle is to treat wastewater to sufficient quality to return it safely back to the natural environment. This is possible with responsible management and available technologies.

There are many water uses in cities that result in dirty wastewater. Domestic wastewater is polluted with microbiological pathogens, cleaning products and medicinal residues. Industrial wastewater contains chemicals, and may have a high organic content (e.g. from food processing) with a high oxygen demand (which, if discharged to surface water, will use up oxygen and deprive natural species). Hospitals are a source of pollution from medicines and drugs. Run-off from hard surfaces, especially during heavy rain events, causes road pollution such as oils, fuel and rubber residues to be washed into sewers and water bodies. Herbicides and pesticides used on road verges, railway tracks and in parks, also contribute to pollution.

How wastewater is treated

As with drinking water treatment, there are conventional and widely used methods to treat wastewater. These are separated into ‘primary’, ‘secondary’ and ‘tertiary’ treatment, the level of advancement along this route being dependent on a number of conditions such as degree of pollution, local regulations and the nature and sensitivity of the receiving water body. The main steps in primary treatment are to remove the most visually obvious forms of pollution, and consists of screening, grit removal, oil removal and primary sedimentation. Secondary treatment removes less obvious, but still critical pollution, principally biological oxygen demand. If not removed, the wastewater uses up oxygen in the receiving waters (such as rivers), thus removing its availability for natural species. Tertiary treatment is the most advanced stage, sometimes called ‘polishing’. This stage may include disinfection, removal of nitrates and phosphates (which can cause agal blooms on water bodies), fine filtration and activated carbon filtration (to remove organic chemicals such as medicinal residues).

Wastewater as a resource

Wastewater can provide a range of valuable resources. The organic content contains valuable nutrients. For example, sewage sludge is dried and converted into safe biosolids to be used as fertiliser. The natural breakdown of organic materials produces heat, which can be used to generate energy. Phosphates can be extracted for use in fertilisers (a resource which otherwise relies on mining).
The water component itself can be recycled and re-used for uses appropriate to its quality, for example, to irrigate parks or for non-potable industrial uses.

Maximising the potential of wastewater as a resource is essential to sustainable water management. Instead of using new energy and chemicals for treatment, they can be extracted from it. With advanced treatment, treated wastewater can be used to recharge aquifers, and even be directly re-used for potable purposes, although this will remain a political and social hurdle in most cities for some time to come.

In addition to its functional roles, for water supply, transport, washing and industrial processing, water provides a critical role in the well-being of cities. This is most obvious for surface water bodies such as rivers, lakes and coastal waters, which are important for recreation (waterside walks, boating, bathing, sport fishing). Water also has a less direct but equally important role in supporting urban wildlife, such as vegetation, birdlife and animal life, even insects, all of which add to the health, attractiveness and biodiversity of cities. Water bodies often form a central feature in urban parks.

Wastewater collection, treatment and reuse

Legend
(1) Primary treatment
(2) Secondary treatment
(3) Tertiary treatment
(4) Sewer system and collection
(5) Separated wastewater treatment, e.g. industrial plants
(6) Uncontrolled system
(7) Water reuse for groundwater recharge
(8) Water reuse for agricultural irrigation
(9) Other forms of reuses, e.g. decorative, landscape irrigation.

Figure 7: Wastewater collection, treatment and reuse. (Artwork by Natalia Głowacka, 2016, Prievidza, Slovak Republic)

Flood risk

Flooding is a significant physical threat in many cities. The threat has been made worse by human interventions over the past century or more, by land use changes and modification of water bodies, and is predicted to become worse as a result of climate change. For most watercourses, periodic flooding is part of the natural water cycle with return periods ranging from a few years to many decades or even centuries. There is an element that flooding is an inevitable periodic occurrence. However, the risks and impacts are made worse for many reasons, which include: restricting natural flood plains, covering the ground with non-permeable surfaces (roads, parking areas, buildings, etc.), removal or change of vegetation in upstream river basins (especially of woodland), and the straightening and channelling of water courses. Even flood defences can have a negative impact as they can push the flood impact elsewhere.

Building on flood plains creates two main risks: placing people (especially homes) directly within 'at risk' zones, and helping to push the flood waters to areas not previously at risk. The channelling away of storm water via storm drains and sewers, instead of allowing water to infiltrate locally, also adds to flood risk along the receiving water courses.

Flood risk can be significantly reduced by returning flows to a more natural regime. This includes managing flood plains, to allow them to absorb flood flows (very often outside of the city), and avoid future building on flood plains; using more permeable and semi-permeable surfaces; discouraging the trend of sealing the land by concreting over it and investing in upstream river basin measures to 'hold back' more flow (known as natural water-retention measures).

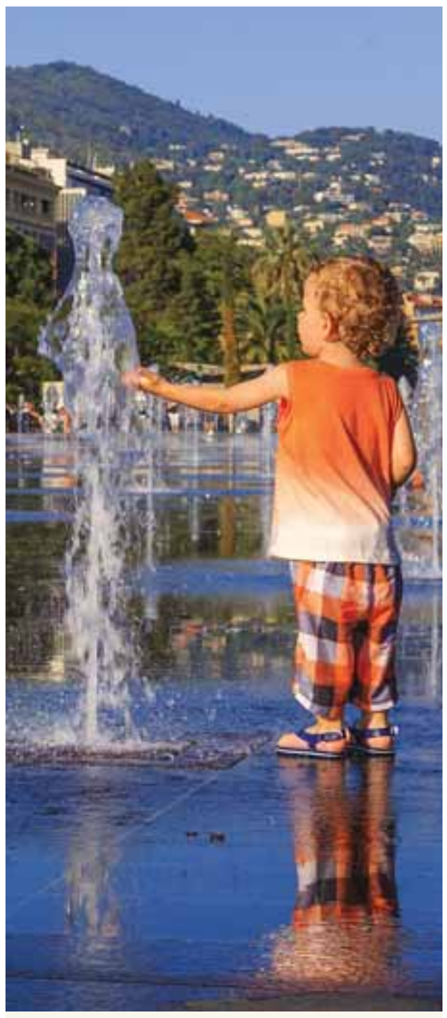
Flooding in the city © egd / Shutterstock.com

The integration of water into daily urban life

As the sections above demonstrate, water is a key part of so many aspects of daily life, both in our personal interaction with it, and its role in the many services and products we use. These sections also show how the many aspects are interlinked. We need water, but our actions also impact on it. In principal, water is a renewable resource, but it becomes non-renewable if we over-use it (especially in locations, and at times of water scarcity), or if we pollute it. To ensure a sustainable safe and clean water supply, cities need to use water efficiently, avoid polluting natural water bodies, and ensure that wastewater is adequately treated.

Protecting and managing upstream river basins helps achieve two major goals: to protect the quality of raw water, and to reduce the likelihood and impacts of damaging floods. Avoiding pollution of downstream river basins will contribute to a healthy and sustainable water cycle.

Amsterdam city with boats on canal in Holland
© egd / Shutterstock.com



Promenade du Payon in the center of Nice, France.
© goga18128 / Shutterstock.com

Working with the local climate and geography

Responsible water management is much more critical in climates already considered to be water scarce. Cities in drier climates often use much more water per inhabitant, for example to irrigate private gardens, parks and the sides of roadways, and for swimming pools. This can partly be addressed by accepting that the city does not need be so green, and by using appropriate plants needing less water. There should also be more incentives, but through appropriate pricing to encourage greater water efficiency.

Every citizen has a responsibility

While regulators and municipalities have a significant role in city water management, each citizen has a personal responsability to use water wisely. Each person can make choices about using water efficiently and avoiding waste, about using products or services with a smaller footprint, about how they use chemicals (for example for cleaning, or medicines) and how they dispose of them (including unused medicines).

Understanding the Urban Water Cycle

Hydroelectric power plant © ZoranOrcik / Shutterstock.com

Water and energy nexus

Water is connected to many aspects of the life, health, character and success of a city. One of the most important links is with energy. Water is required for energy production, and energy is required to abstract, transport and treat drinking water.

Energy generation uses water for cooling, hydropower, mineral extraction, fuel production (including fossil fuels and biofuels), and control of emissions. In many countries, energy production is for the largest industrial use of water.

For example, in the USA, thermo-electric cooling represents 41% of water abstraction (NCLS, 2014) (although most of that is returned to the local water cycle). Although energy production and its water use is mostly outside of the city, they are relevant to the city's environmental and resources footprints.

Water supply requires energy for pumping from water sources and through the delivery network, for treatment, and for collection and treatment of wastewater. In the USA, water systems consume 13% of energy used, and use 25% more energy than for residential and commercial lighting (NCLS, 2014). In Europe, after manpower, energy is the highest operating cost item for most water and wastewater companies (Makropoulos et al., 2012). In Australia, water-related energy in cities is equivalent to one-third of the total energy use of all Australian industry (excluding transport) (Kenway, 2014).

In the most extreme cases, a limitation of one resource can severely restrict access to the other. In the hot 2003 summer in France, some nuclear power plants were required to stop operating, at a time when electricity demand was high, because discharged cooling water was adding further heat to already overly warm rivers (Duval Smith, 2003).

Coordinated efficiency and synergy projects will benefit the sustainability of both water and energy resources. Some examples relevant to cities are as follows:

- Improving energy efficiency (through technology and citizen information programmes) will reduce net water use, even though cities may have limited direct influence on water use in energy generation.
- Improving water efficiency will reduce the total amount of water used, and thus the energy required for pumping, transport, treatment and wastewater management.
- Off-peak energy can be used to pump water up to storage reservoirs, allowing energy to be recovered during peak demand times as water flows back down through turbines.
- Energy can be abstracted from wastewater – from biogas and from burning of dried solid waste.

Connections between water and energy

Legend

(1) Precipitation involves natural energy from sun and wind

(2) Electricity from hydro-power

(3) Power plants cooling uses water

(4) Water vapour from energy making

(5) Energy grid distributes energy to users

(6) Drinking water needs to be pumped and uses energy

(7) Wastewater treatment plant needs energy to clean the used water

(8) Energy is used for agricultural irrigation

(9) Energy and water consumption are closely related in our homes, e.g. for heating and pumping

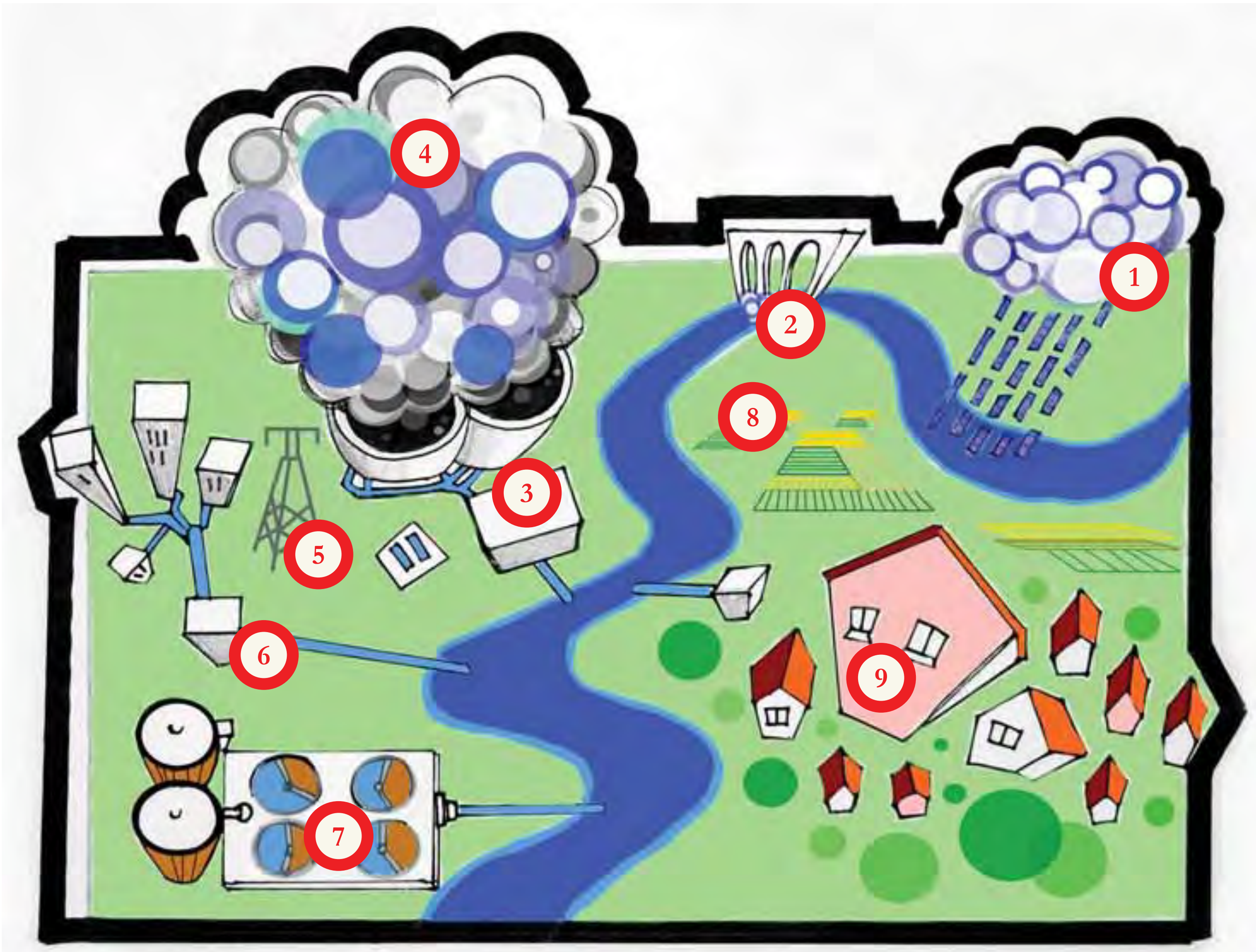


Figure 8: Connections between water and energy. (Artwork by Natalia Głowacka, 2016, Prievidza, Slovak Republic)

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Governing the Water Challenge

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Water-related challenges faced by cities today and in the future

The dominant challenges differ to some extent between cities in developed and developing regions. In developing cities, a principal challenge is keeping up with rapid population growth, including urban immigration. It becomes a priority to ensure both an adequate supply of safe drinking water, and a safe and effective wastewater collection system, at the same time meeting the demand of continuous growth (Koop and Van Leeuwen, 2016).

There are two major barriers to keeping up with demand. One is the cost, which many developing cities cannot afford, and the other is governance, given the complexity of managing major infrastructure development in a dense and rapidly growing city. An additional complexity is that many new immigrants to developing cities are poor, often settling in unauthorised housing areas (slums and shanty towns), which have no existing or planned water supply or wastewater infrastructure, and for which there are no official plans to develop them. The absence of wastewater and general waste control also adds to the pollution risks of rivers and aquifers, which may provide water supply for other parts of the city.

The costs of infrastructure is also a challenge for developed cities, many of which have old systems, some more than 100 years old. The cost of urban infrastructure is staggering. UNEP (UNEP, 2013) estimates that between 2005 and 2030 about US$ 23 trillion (23 million million) will be required to refurbish old water system infrastructure (mainly in developed cities) and build new infrastructure (mainly in developing cities).

These are costs for which the demand and needs are too great to ignore.

The UN (United Nation, 2012) predicts that by 2015, about two billion people will experience water shortages and that two thirds of the world population will be affected by water scarcity. Given that population growth and immigration will be predominantly urban, cities are where most of the pressure will be felt. Urban water shortages have two main causes. One is economic water scarcity, linked mostly to inadequate infrastructure. The other is physical water scarcity associated with the pressures on water sources, caused by one or a combination of the following: increased demand, drought and reduced rainfall.

For many cities, water brings an increasing threat in the form of floods, which can cause significant infrastructure damage, loss of life, and personal stress through damage to homes. All of these impacts have a significant cost, which is often difficult to fully quantify, but which has shown an increasing trend in recent years. In Europe, where floods are the most prevalent natural hazard, costs were estimated at an average €5 million/year in the 2000s, but which could increase to €23 million/year by 2050 (Jongman et al., 2014).

The wise view is that cities should plan and invest in advance, to prepare or adapt for the challenges ahead. However, the limitation of funds in many developing regions, and the scale of some costs even for developed regions, as in the infrastructure example, mean that solutions are more often applied in a reactive and ad-hoc fashion. Unfortunately, it often takes a major damaging event to force investment. For example, as a result of major sea flooding in the Netherlands in 1953, which caused major damage and loss of life, the Delta Plan was implemented to protect cities and much of the country from similar flood in the future. A 10-year drought in Melborne, Australia forced the city to invest in rigorous mitigation measures, including a desalination plant, rainwater capture systems, and wastewater re-use technology, Melborne is now classed as a 'water-sensitive city'. (Koop and Van Leeuwen, 2016).

Water governance

It is clear from the forgoing discussions that meeting current and future priorities in sustainable urban water management will be a continuous challenge. To tackle these challenges, it is necessary to take numerous aspects, interests and stakeholders into account (SWITCH, 2011). However advanced the science and technology may be, and even if comprehensive funding is available, good governance is an absolute requirement for success.

The Global Water Partnership (GWP) provides a widely accepted definition of water governance: "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society and for different purposes." According to the GWP, water governance covers the mechanisms, processes and institutions by which all stakeholders - government, the private sector, civil society, pressure groups – on the basis of their own competences, can contribute their ideals, express their priorities, exercise their rights, meet their obligations and negotiate their differences.

Obstacles to successful water governance exist at several levels. The biggest challenges, according to the OECD (OECD, 2011), include institutional fragmentation, ambiguous legislation, poor implementation, limited local scientific and technical capacity, unclear allocation of roles and responsibilities, and unstable or insufficient revenue and funding. There are often no long-term strategic plans or sufficient monitoring of performance. This leads to weak accountability and poor transparency.

Collectively or individually, these obstacles limit the chances of many cities to achieve sustainable water management to meet all critical needs and to the satisfaction of all stakeholders

There are seven key elements to achieving a successful transition to good water governance
(Koop and Van Leeuwen, 2016)

1. Develop a shared long-term vision between stakeholders.

2. Involve civil society and the commercial sector, along with stakeholders: recognising that citizens and private businesses can individually contribute to success.

3. Manage the process and expertise: to address the complexity of the challenge, conflicting interests, and the need to remain focused on a long-term vision.

4. Stop excessive focus on technology development: recognising that good governance is equally essential for success.

5. Make data accessible, and share knowledge.

6. Carry out a thorough cost-benefit analysis and remove financial barriers: Success is not dependent on simply providing more money. Limited finance can drive innovation, improve stakeholder cooperation, and help leverage new funding sources.

7. Monitor implementation: Legislation and a good strategy must be supported by a demonstration that implementation and achievements progress as intended.

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Storm Water **Management**

Author(s) | ***Mona ARNOLD***

Flooded road and railway at a coastal city © Four Oaks / Shutterstock.com

Stormwater management

Urban stormwater is one of the biggest problems facing city infrastructure waterways today. Urban cloudbursts and the resulting rapid stormwaters that overflow along surfaces and in networks are more and more common in cities due to climate change, increasingly impervious surface areas, aging infra-structure and often undersized, centralised stormwater networks. Contaminants such as metals, pathogens and pesticides are common in runoff.

Image 5: Local early warning system for urban flooding from heavy rains (Source: Korkealaako and Piira, 2013).

Fast alarm for management of floods

The need for ICT solutions to support local early warning systems for urban flooding is increasing with an increase in the number of extreme weather events (Jongman et al., 2014). Considering that more than half of the world's natural disasters are floods, which affect millions of people each year, the potential for making savings with 'fast alarms' is clear (Korkealaakso, 2015; Leonardsen, 2012; Motaghi et al., 2015). Cities, the property sector, rescue authorities and governmental authorities all need early warnings of heavy rain and floods in order to minimise the harm to people, property and business, and to inform the relevant actors and authorities. Local early prediction of flooding gives time to react. Urban planners can apply detailed surface and underground 3D flow simulations with different cloudburst or climate change scenarios when designing effective solutions to manage storm water quantities and qualities.

Helsinki tested a 3D flood forecast simulator prototype that can link to and be continuously calibrated by live data sources (e.g. short-term weather predictions in wireless sensor networks), with a wide range of dynamically integrated models on surface, stormwater and sewer networks, water quality, and underground and building space models to provide detailed, accurate forecasts of water levels, flood depths, flows, velocities and water quality parameters in real time. Other integrated data included street-level 3D models of urban areas, weather and water gauge measurements, surveillance cameras, etc, connected to data communication technologies including, GPS, Google Maps, and IOS-based tablet and smartphones. The test site for the system was the centre of Helsinki, the capital of Finland, (which is particularly prone to flooding) both above and below ground. The flooding risks were evaluated from the property owners' point of view. The prototype raises alerts by reporting targeted information on flood events to key building security personnel, rescue services, local control room operators, etc. The system reports exact locations in the target area that are, or will be, in a critical situation now or in the coming minutes or hours. Further, other flood-related information, such as emergency procedure recommendations, are integrated as an output in the system (Korkealaakso and Piira, 2013)

Image 6: Heavy rain data collection and flood forecast (Source: Korkealaako and Piira, 2013).

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Green spaces

Rapid urbanisation has led to an increase in the number of buildings, and an associated decrease in natural greenery. As well as changing the visual landscape, the loss of green spaces has created various environmental issues, many of which directly affect human livelihoods. For instance, removing vegetation means rain is less likely to soak into the ground and more likely to run off, thus increasing the risk of floods.

One main step in mitigating the effect of a cloudburst is to delay precipitation with higher intensities as long as possible. Typical measures include green roofs (Image 7) and rain gardens, inundation of parks, etc. However, the required size and space needed for stormwater retention measures can be a challenge.

Compared to other strategies, green roofs are relatively low impact as they utilise existing unused space. As a result, they have become rather popular across Europe (Yang et al., 2015).

A typical green roof consists of several layers, including a vegetation layer, a medium layer, a filtering-drainage layer, and a roof deck layer. However, the ability of green roofs to retain water varies across sites due to climate and vegetation type, as well as the structure and properties of the layers and the roof.

In addition to retaining water, vegetation on a green roof shades surfaces and removes heat from the air through evapotranspiration. These two mechanisms reduce temperatures of the roof surface and in the surrounding air. The surface of a vegetated rooftop can be cooler than the ambient air, whereas conventional rooftop surfaces can exceed ambient air temperatures by up to 50°C (Liu and Baskaran, 2003).

Image 7: Green roofs (Source: Braskerub et al., 2015)

Image 8: Rain garden in Oslo (Source: Braskerub et al., 2015)

Climate adaptive (permeable) surfaces

New materials and structures allow stormwater to infiltrate into base layers and subgrade rather than burdening stormwater collection systems or transporting run-off pollutants to local water bodies, as traditional pavements do. The groundwater table also stays higher which enhances vegetation and reduces the heat island effect (European Commission, 2012). Pervious pavements and surface materials have been developed in Japan, and are used widely in the USA and central Europe. Suitable applications for these materials are, for example, parking lots, pedestrian walkways, roads with limited traffic and flood risk areas.

Pervious pavements (Source, VTT)

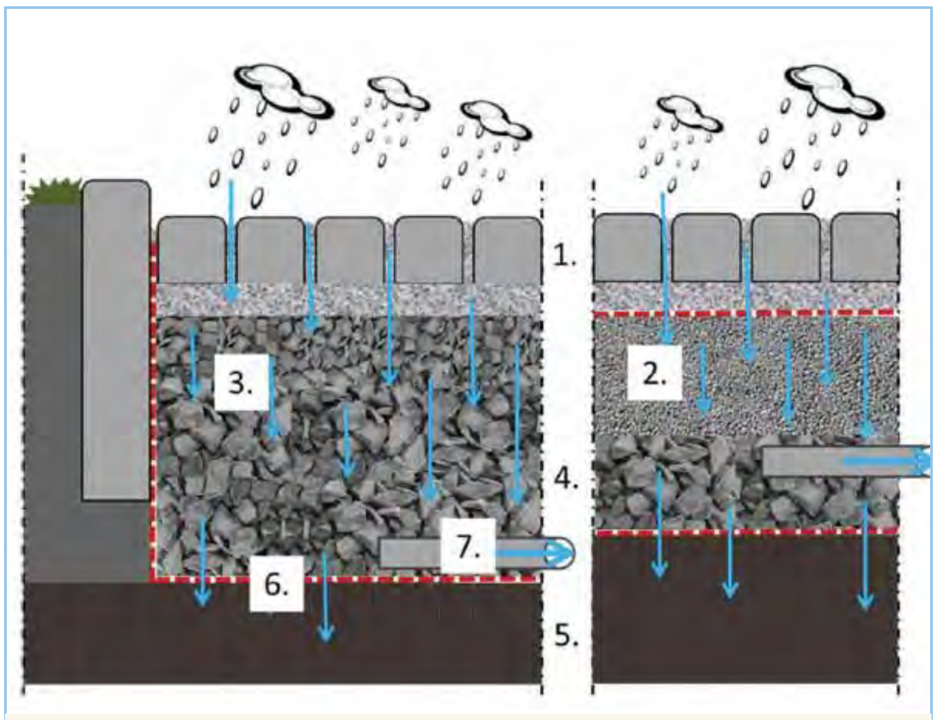

Figure 9: Pervious pavements (Source: VTT)

1. Concrete stones with pervious joints
2. Pervious concrete (as base layer)
3. Base layer - aggregates (crushed rock)
4. For water storage/retention
5. Subgrade
6. Geotextile
7. Piping to channel water elsewhere

Permeable surfacing combined with sub-surfacing materials has been less utilised in northern countries due to performance uncertainties for winter durability. Few studies concerning winter performance exist, i.e. Niemeläinen et al., 2015. In addition to reduced risks of structure failure due to freeze-thaw resistance, the pervious pavement cannot be prone to clogging (by fine debris) and should be easily cleaned.

Image 9: Pervious pavement materials. (Source: VTT)

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Storm Water **Management**

Engineered infiltration systems – functional filters

Engineered infiltration systems also have the capacity to remove contaminants from stormwater (like POC, heavy metals, pesticides, etc.), however, the potential of these systems has not yet been fully exploited or optimised. With improved designs based on known mechanisms of contaminant removal, engineered infiltration has the potential to provide reliable treatment of urban stormwater, resulting in a water resource that is safe for aquifer recharge or urban stream restoration.

The mechanisms by which the chemical and biological contaminants of concern can be removed during infiltration through porous media systems include filtration, sorption, and chemical and biological transformation. The opportunities to effectively optimise treatment of stormwater include choice of infiltration media, manipulation of system hydraulic behaviour and manipulation of redox conditions.

Examples from selected cities

Copenhagen

To combat flooding caused by cloudbursts — or sudden, heavy rainfall — and cope with climate change, the City of Copenhagen originally examined sewer system upgrades but instead decided to incorporate green and blue elements, a more cost-effective option that would also renew the urban environment. The city expects to invest about US$1.5 billion in climate adaptation measures in the next 50 years, and the actions will be based on results from St. Kjeld, a low-lying neighbourhood, which will serve as a testing ground.
One of the reasons St. Kjeld was selected is its abundance of asphalt. The city envisions transforming 20% of the neighbourhood into green space and managing 30% of stormwater locally, so that it does not enter the sewage system. In the main square, large stormwater collection tanks have been installed to collect some 4 300 m^3 of runoff.
In addition to creating rainwater harvesting systems and urban green spaces to soak up storm water runoff, rooftops and other features will divert rainwater onto specific streets that will act as channels, leading rainwater to the harbour and becoming temporary canals during floods. Pedestrian walkways and basement entrances will be raised above street level.

Image 10: Copenhagen is using nature-based solutions to mitigate risks from storm events.
(Source: http://www.fastcoexist.com/3041580/how-copenhagen-is-preparing-for-the-next-monster-storm [Last access: 23/01/2017])

Rotterdam

Benthemplein, the world's first full-scale water square, opened in Rotterdam, the Netherlands in 2014. The square can retain nearly 2 000 m^3 of water. During dry weather, the square can host a number of sports, theatre and relaxation activities. The city and district water board included input from local residents, including students of the adjoining school.

Rotterdam's abundant impervious surfaces guide rainwater to surface waters and sewers. Increasingly intense rain events have overwhelmed the city's stormwater infrastructure, resulting in flooded streets and basements. The Benthemplein area was in a high-flood risk zone. It is one among a host of smart solutions applied in Rotterdam, such as green rooftops, water storage facilities, and the Bellamyplein, a smaller version of the Benthemplein.

When it rains, water from surrounding streets is directed into the square, which fills up. This pools the water, relieving pressure on surrounding drainage facilities. The square then drains at a much slower rate through a central point. Filters are fitted on the drains feeding into the plaza, keeping the pooled water clean. The plazas are also designed in levels and channels, so that rainfall actually adds to the appeal of the square, opening up little ponds. Rivers and water features have collected some 4 300 m^3 of runoff.

Image 11: First Full-Scale Water Square Opens in Rotterdam.
(Source: http://stormwater.wef.org/2014/03/first-full-scale-water-square-opens-rotterdam/ [Last access: 23/01/2017])

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Energy Recovery From Wastewater

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Water Treatment Plant at twilight © mr.water / Shutterstock.com

Energy recovery from wastewater

Water-source heat pumps are an efficient way to produce hot water for space- and process-heating from relatively cold sources.
Discharged wastewater offers a reliable source of heat at any location and at a relatively higher temperature compared to surface or groundwaters. Effluent temperatures are above 10°C throughout the year for most plants, presenting adequate temperatures for heat pump operation. A number of heat pumps on the market can produce the hot water temperatures required for process- and space-heating at a wastewater treatment plant (WWTP). Recovered heat could be utilised for warming the buildings of the water utility or heating water. Processes such as anaerobic digestion and sludge drying could also benefit from the recovered heat.
Heat can be recovered immediately after the wastewater is produced in the house. These applications are usually small-scale, and the recovered heat is used for pre-heating domestic hot water. In addition, there are applications in which the heat recovery system has been installed in a sewer. With this option, the heat transfer area can be relatively large. Conventionally, heat recovery systems are installed at the wastewater treatment plants after the wastewater is treated in order to avoid fouling of the heat exchanger. This also solves a potential restriction with recovering heat before the water treatment process if the temperature drop can affect the biological water treatment processes, resulting in a less efficient purification.
Wastewater from industry and municipalities always contains a certain amount of heat. The temperature of discharged wastewater can be considerably higher and more stable compared to the sourroundings. Recovered heat could be utilised for warming the buildings of the water utility or for heating water. Processes such as anaerobic digestion and sludge drying could also benefit from the recovered heat. Furthermore, heat is often transferred into a district heating system. The use of heat-pump technology could also increase the overall efficiency of the heat recovery system by being able to provide cooling energy during the summer season.
Hammarbyverket in Stockholm, Sweden, is the largest wastewater heat recovery plant in the world, receiving a wastewater discharge of 4 000 – 18 000 m^3/h. The plant has installed seven heat pumps, with a total capacity of 225 MW. These heat pumps recover heat from treated wastewater, producing 1 235 GWh of heat annually. The produced heat is used to warm up 95 000 residential buildings. In order to maximise production, the plant also produces cooling energy for the district cooling network. In addition, a small, 315 kW turbine is installed in order to produce electricity from the hot side stream (Fortum, 2013).
The temperature of the incoming wastewater from the wastewater treatment plant in Hammarbyverket varies between 7 and 22°C. After the heat pump system, the temperature of the effluent is 1 – 5°C. Even though the heat-pump system can raise the temperature to 80°C, two bio-oil and two electricity boilers are installed in order to increase the temperature to 120°C during peak consumption hours and colder periods.

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Water Distribution Systems

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Hydraulic Pressure Gauges installed on Hydraulic Equipment © Scruggelgreen / Shutterstock.com

Cost of supplying water

Water is a natural resource in lakes, rivers and as groundwater. However, water needs to be processed before reaching your tap as safe drinking water. This is carried out by a water utility company which can be public or privately owned. Wastewater collection and treatment may be undertaken by the same utility or separate ones. A water utility typically operates through four main departments: (1) planning and design of new infrastructure; (2) maintenance of existing infrastructure; (3) operations and control; and (4) customer services. All require significant technical, financial and human resources, with costs incurred at each stage:

. Water abstraction from the raw surface or groundwater source has an energy cost, and may incur an annual permit fee.
. Water treatment requires specialised filters, and consumes chemicals and energy.
. Treated water is delivered to consumers via a distribution system of pipes and tanks, which has a cost for construction and maintenance, and for pumping water through it.
. Customer services include quality and usage monitoring, billing, and responding to problems and concerns, with staffing and overheads cost.
. Wastewater is collected from each property, and transported via separate pipes to wastewater treatment works, with construction, maintenance and pumping costs.
. Wastewater treatment for safe discharge requires filters, chemicals and energy.

The utility also needs a budget for unexpected events and emergencies, such as major leaks and flooding.
As an example of the scale of management and investments required, consider Severn Trent Water (Severn Trent, 2015a), which provides water and wastewater services to 3.3 million households and businesses in south central UK. It supplies 1.9 billion litres of drinking water via 48 000 km of pipeline, and collects and treats 2.5. billion litres of wastewater. It operates 181 water treatment works to clean raw water (from groundwater and surface-water sources) to the highest drinking water standards. In 2015 it invested £547 million (€650 million) in water supply infrastructure (Severn Trent, 2015b)equivalent to around £165 (€200) per connected property. Severn Trent Water employs around 5 000 employees to provide continuous services to its customers.
Globally, water-related infrastructure has a higher value and cost – for current and future investments - compared to those for energy, transport and ICT sectors. The global future investment for water up to 2030 is forecast to require $22.6 trillion, more than energy and transport combined, as summarised in Table 1.

Table 1: Forecast investment costs required globally by 2030 (Source: UNEP, 2013)

Infrastructure	Costs (in trillion US$)
Water systems	22.6
Energy	9
Road and rail infrastructure	7.8
Air- and seaport	1.6

Leakage and water losses in water distribution systems

Background

A water distribution system can collectively comprise thousands of kilometres of pipework. From the treatment works, water is carried first via large-diameter transmission pipes, crossing the city, which then branch into progressively smaller pipes for sub-regions, individual streets, and eventually to individual properties. Piping systems are prone to leaks which may occur at joints or where aged pipes are heavily corroded (Image 12). In much of Europe's older cities, water infrastructure is ageing and deteriorating, making leakage management one of the biggest challenges (European Commission, 2015; Farley and Trow, 2003). Leaks are of three main categories (Lambert et al., 1998): 1) reported leaks 2) unreported leaks and 3) background leakage. The reported leaks are generally bigger leaks which quickly become obvious. Unreported leaks are large leaks which are only detected by dedicated surveys, and may go undetected for long periods. Background leakage is the sum of very small leaks and seepages, nearly impossible to detect individually. Their control requires costly replacement of old infrastructure combined with pressure management.

Pressure control

Water must be supplied at an appropriate minimum pressure to consumers to ensure reliable and strong flow at the taps. Pressure is also important to prevent pollution from entering the pipes at leakage points. On the other hand, the pressure cannot be too high since this would increase leakage rates and contribute to pipe breakages. Pressure control must also take account of wide variations in consumer demand during the day and night. High consumption rates reduce pipeline pressure, while low demand results in increased pressure, which could cause damage and more leaks. The aim of pressure control is to maintain constant and low pressure over time, often using pressure control systems to increase or reduce pressure in specific parts of the network.
The more traditional, but still most accurate methods to detect leaks and bursts use acoustic tools such as listening sticks. However, these are resource-intensive. Support can now be provided by sophisticated ICT monitoring and modelling systems.


Image 12: Corroded pipe which was a source of major burst in Leicester 2015. (Source: DMU, 2015)


Image 13: Repaired pipeline after the major burst in Leicester 2015. (Source: DMU, 2015)


Image 14: The detected leak within 1m of model prediction (Source: DMU, 2015)

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Water and energy in water distribution systems

The purpose of a water distribution system is to convey water from the sources and treatment plant to consumers. If a source is at a higher elevation than the consumers, the water flows under the force of gravity, requiring little or no energy. In the opposite situation, water must be pumped against gravity, requiring energy. Additional energy is required to overcome the friction between water and the pipe walls.
The energy required to pump water through a network can be significant. For a city of 300 000 inhabitants lying at 50 metres above its water source, the energy required can be 12 000 kWh, the equivalent energy consumed per day by almost 1 000 households in a typical European city.

Figure 10: Generation power from PRV bypass to supply electronic instrumentation. (Source: DMU, 2015)

Technology and ICT for efficient pumping and energy use

User demands in a water distribution system vary during the day, with morning and afternoon peaks and low levels of consumption during the night. Traditionally, most pumps were set at a fixed speed whose flow rate was changed by adjusting valves. This is inefficient as a lot of energy is wasted in pumping against partially closed valves. New technology allows for variable-speed pumps, which are much more flexible to varying demand and more energy efficient. The changing demand patterns during a 24-hour period can be complex. The variability can be partially optimised through the buffer effect of large storage tanks and reservoirs. Much more flexibility can be provided by ICT innovations, which combine monitoring and predictive modelling of demand to reduce total energy use. In more advanced networks, the rate of water treatment can also be adjusted. Energy savings of as much as 10% can be made, equivalent to the energy demand of 100 households.

Image 15: Energy recovery from flow in a pipe. (Source: DMU, 2015)

Harvesting of energy in water distribution systems

Pressures in a water distribution system can sometimes be too high, because of gravity or over-pumping. This excess pressure can be used to generate electricity. One example is a micro-turbine installed in a pressure relief valve (PRV), as illustrated in Figure 5.2. The excess pressure turns a small turbine to create low-level electricity, limited to powering measurement and control instrumentation around the valve. A more radical solution is to replace a PRV with an electricity-generating turbine (Budris, 2008; Lucid Energy) as illustrated in Figure 5.3. This is ideal for generating electricity from gravity-driven flow. Consider a city of 300 000 lying 100 metres below its water source. The energy generated could be nearly 10 000 kWh, enough to power 700 households.

Figure 11: A major pump station in a water distribution system. (Source: DMU, 2015)

Image 16: A major pump station in a water distribution system. (Source: DMU, 2015)

ICT in water distribution systems

There is an urgency to improve the efficiency of water distribution systems, especially to reduce leaks, and water and energy consumption. ICT technology is an important enabler to achieve this.
As mentioned above, a water utility has four main categories of activity: (1) planning and design; (2) maintenance; (3) operations and control; and (4) customer services (Figure 12).
For digitalisation of the water supply system, the first step is to gather all available information, traditionally on paper records, and transform them into electronic form, stored in databases which can be searched and queried as needed. Geographical mapping of the network has become an indispensable tool for efficient management, monitoring and maintenance planning. Previously static databases are now replaced by ones that are updated in real time combined with live mapping of events and actions. The benefits of such ICT tools are invaluable for operational and financial efficiency. With increasing computing power, 3D visualisation is being introduced in some systems.
A large challenge that remains for many systems is finding an efficient way to integrate incompatible databases.
Computer modelling to predict demand and associated flows and pressures is becoming an increasingly common tool for water supply management. This benefits from comprehensive real-time monitoring throughout the system due to availability of advanced, but cost-effective sensors and wireless communication.
To date, ICT technology focuses mainly on water supply, but there is a great potential to support water consumers in reducing their demands and rationalising their water usage. Smart metering can help consumers understand how they use water, and guide them towards improved practices. ICT can also facilitate closer collaboration between water suppliers and their customers.

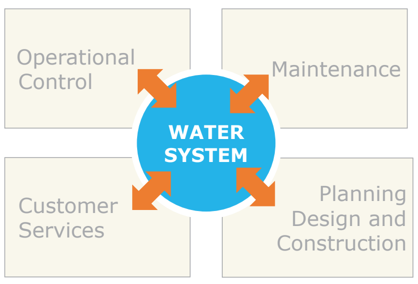

Figure 12: Groups of activities in a water company. (Source: DMU, 2015)

References:
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Water Distribution Systems

Physical and cyber security issues

Background

Disruption of water supply systems, unintentional or deliberate, can have serious health and economic consequences. With a rising number of incidents, physical and cyber security of water systems is becoming more important. A recent survey by the American Water Works Association (AWWA) (Murphy et al., 2005) found that, of 193 documented incidents in the US, 182 were classified as deliberate. The greatest number of threats was associated with intruders with specialised knowledge of the network. Of the deliberate actions, 7% were by utility employees and 12% by terrorists (domestic and foreign). The most common form of malicious act is pollution of the water supply with chemical or biological agents. Physical damage is also common, usually caused by vehicles or explosives. Physical localised damage is visible and can be repaired relatively quickly. Contamination incidents are more difficult and slower to rectify.

Image 17: Control centre of a major water distrbution system. (Source: DMU, 2015)

Contamination detection

Contamination incidents (whether accidental or malicious) are monitored via a network of sensors. There is no sensor which can detect all possible contaminations, so a proxy approach is adopted. Early detection depends on identifying unexpected or sudden changes in conventional parameters such as electrical conductivity, residual chlorine and pH. How they change can be indicative of the nature and origin of the contamination, perhaps with the help of computer analysis. More specific sampling is then carried out to confirm and determine the nature of the incident, followed by an appropriate corrective action or emergency response.

Cyber security

Cyber security, such as the prevention of hacking into computer control systems, is a growing concern. The majority of water utilities use SCADA (Supervisory Control and Data Acquisition) computer-based systems to monitor and control their water systems. SCADA systems read data from throughout the network and control processes such as pumps, valves, water levels and pressures. Disruptions to the control system can have significant consequences such as equipment failure and burst pipes, resulting in interruptions of supply to customers and costs of potentially millions of euros.

Malicious disruptions can be caused by internal employees with a grudge, or external hackers. There is an increasing number of serious incidents around the world.

The industrial control community is now collaborating and sharing the information about cybersecurity incidents via a publicly available website, http://www.risidata.com. Its front page describes it as "A database of incidents of a cyber security nature that have (or could have) affected process control, industrial automation or SCADA systems." It reports that cyber incidents in the water and wastewater industry have increased of 60% in recent years. Improvements to SCADA security are made by removing vulnerabilities and by improving installation, configuration, and maintenance practices.

Hacker on a laptop © frank_peters / Shutterstock.com

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Smart water meters

Many companies (Thames Water) are replacing analogue electricity, gas and water meters with smart meters, which have a dual purpose - first, to provide real time consumption data to the utility provider, and second, to allow users to more accurately monitor and manage their consumption patterns. A smart meter (Image 18) typically transmits its data via a radio or mobile phone transmitter. To date, smart energy meters are more common than smart water meters. Smart meters can automatically switch between tariff bands linked to usage and time of day. The UK experience indicates that metered customers tend to use 12% less water on average and are proactive in removing leaks inside properties. However, there is some opposition to smart metering due to concerns about higher prices, privacy intrusion and the potential to restrict or cut off a supply remotely (Stop Smart Meters). A new smart metering pilot project in an area of London (by Thames Water) will be a wireless network which will automatically collect water usage data every 15 minutes. The supplier will achieve more detailed understanding of where and how much water is being used across the water network, enhancing its ability to pinpoint and repair leaks. Customers will be able to view their water consumption online around the clock, gaining greater control of their usage and their bill, and will be offered practical support including fitting free water-saving devices and free repair of leaks during the pilot period.


Image 18: Smart water meter. (Source: DMU, 2015)


Image 19: Non-invasive 'clip-on-pipe' smart water meter. (Source: DMU, 2015)

Future integrated utility services provision

Separate utility services such as water, gas and electricity are mostly delivered to end-users via separate infrastructures (Figure 13). Distinct infrastructures in proximity of one another often result in duplication of maintenance and repair works, such as road digging, undesired interactions (e.g. flooding of electrical cables by pipe bursts), and third-party damage being caused to one service infrastructure while repairing another. A project aiming to address these problems is the 'All in One' project in the UK (EPSRC, 2011-2013). This involved looking 50-100 years ahead and considering how utility services provision can be better integrated (Karaca et al., 2013a) There is also a growing realisation among water companies that they should think more in terms of providing a broad service to customers rather than just supplying a single product - water. More broadly, they help satisfy human needs such as nutrition, hygiene, sufficient quality and quantity of drinking water, and support thermal regulation (heating and cooling).
One component of the All in One project was to develop futuristic visions of utility provision, or 'vignettes', and for which gaps in science or technology could be identified (Karaca et al., 2013b). One vignette example is "The Blood of the City", inspired by the human body. The same pipelines would deliver water and energy to households, analogous to how blood delivers energy and fluid to individual cells. It could mean fuel being transported in dissolved or suspended solid form in water. A challenge would be to separate the fuel and water at point of use, to ensure safe drinking water (Karaca et al., 2013a).
The project also considered how to change the approach of managing and integrating existing infrastructures, for example by using locally available natural resources and recycling utility service by-products (Ulanicki et al., 2012). For instance, water can be obtained from rain, air or ground; energy/electricity from the sun, wind or the ground. Some service products can be replaced by other products. For example, gas can be replaced by electricity, and heat can be provided by gas or electricity.
A further approach is to assess the combination of services required by a household or community, within the constraints of the existing infrastructure and of natural resources. Using a computerised simulation system, a solution can be calculated to optimise how best to provide the combination of services, taking into account costs, synergies, efficiency and sustainability aspects. This approach can produce customised solutions based on individual circumstances, simplifying global infrastructure and improving the resilience of communities.

Underground infrastructure

Figure 13: Underground infrastructure. (Artwork by Natalia Głowacka, 2016, Prievidza, Slovak Republic)

Legend
(1) Storm sewer pipe
(2) Sanitary sewer main pipe
(3) Cable, TV, telephone, electrical
(4) Water main pipe
(5) Water utilities

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Water
Reuse and Recycling

Author(s) | ***Xavier MARTINEZ, Laura ALCALDE-SANZ, Peter EASTON, Bernd Manfred GAWLIK***

Closing the loop: water recycling in a city

Are we still drinking water that dinosaurs drank?

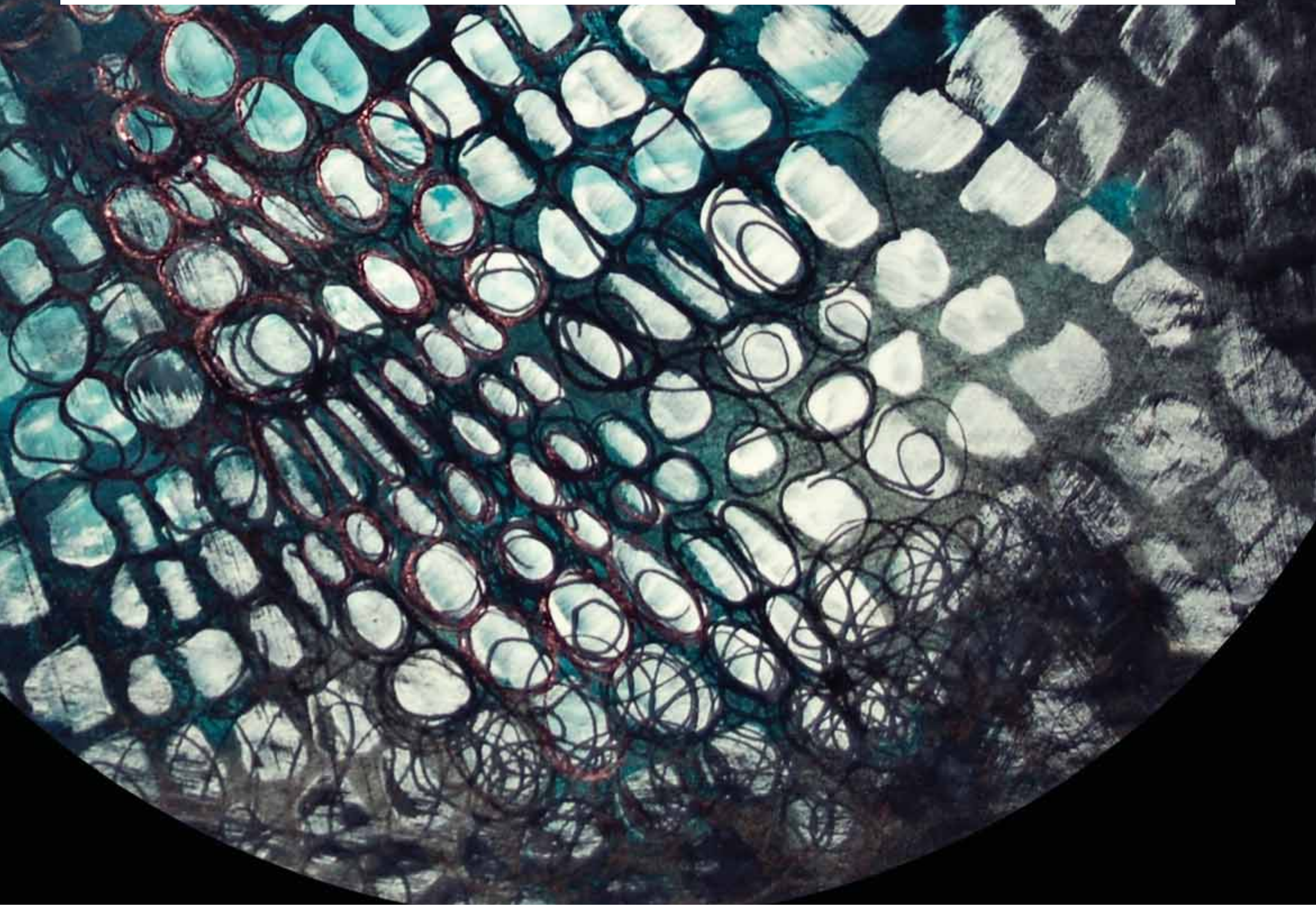
Water evaporates from the oceans, forms clouds, falls as rain or snow, and returns via rivers and groundwater to the oceans. Globally, the places it stays longest are in the deep ocean and in deep groundwater, locked in for up to tens of thousands of years. However, water is also destroyed chemically in photosynthesis (whereby convert carbon dioxide and water to sugars and oxygen) and recovered again in respiration (basically the reverse of photosynthesis, to make energy and CO_2).
We can estimate how much water remains from the dinosaur age from the total amount of water on the planet and the amount of water taken up in photosynthesis each year. Based on this, we estimate that it would take about 100 million years to chemically destroy most of the water. Dinosaurs lived up to 65 million years ago. So, some of the water we drink is the same water they drank, but more than half is different water.

This is why it is so important to conserve water. With a growing world population, more people living in cities, weather and climatic stresses, limited fresh water supplies and the costs of treating water before and after we use it, water quality is a hot topic. As scientists investigate how to keep the taps running and the seas clean in the face of these challenges, we can all do our bit to look after water.

Looking for additional sustainable water supply options is of pivotal importance for our survival. For instance, for dry regions with low rainfall levels or densely populated areas such as cities, it makes sense to recycle wastewater immediately after treatment rather than discharging it into rivers or the sea. In many cases, the recycled water is used only for non-drinking purposes, for example to irrigate parks or to flush toilets. But in the most innovative cases, drinking water is also obtained from recycled water.
To meet future challenges, more research is needed into closed-loop water recycling, such as how to improve testing and purification processes. Current systems are unable to effectively remove certain microbial, chemical and pharmaceutical residues, which is essential if the water is to be reused for drinking purposes.

In the following text, successful examples of recycling water in selected demonstration sites are described and illustrated. The sites are part of a European research project, DEMOWARE (www.demoware.eu), which aims to increase public confidence in solutions based on water reuse and recycling.
The project is guided by SME and industry priorities, and has two central ambitions: to enhance the availability and reliability of innovative water reuse solutions; and to create a unified professional identity for the European water reuse sector.

Although current technology is capable of reaching the quality requirements of all water reuse regulations, operational and capital costs still remain among the main barriers that limit the widespread implementation of water reuse schemes. Innovative technologies and treatment schemes must reduce the overall cost of water reuse by increasing performance and adapting the treatment to site- and end-use-specific conditions.



What is water recycling?

While recycling is a term generally applied to aluminium cans, glass bottles, and newspapers, water can be recycled as well. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a groundwater basin (referred to as artificial groundwater recharge). Water recycling offers resource and financial savings. Wastewater treatment can be tailored to meet the water quality requirements of a planned reuse.

How can recycled water benefit us?

Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use. Recycled water is most commonly used for non-potable purposes (ie. not requiring drinking water quality), such as agricultural, landscape, public parks, and golf course irrigation. Other non-potable applications include using water to cool power plants and oil refineries, for industrial process as in facilities such as paper mills and carpet dyers, toilet flushing, dust control, construction activities, concrete mixing and artificial lakes.

Although most water recycling projects have been developed to meet non-potable water demands, a number of projects use recycled water indirectly for drinking purposes. These projects include recharging groundwater aquifers and augmenting surface water reservoirs with recycled water (normally after undergoing further drinking-water treatment). In groundwater recharge projects, recycled water can be spread or injected into groundwater aquifers to augment groundwater supplies, and to prevent seawater intrusion in coastal areas.

What are the environmental benefits of water recycling?

In addition to providing a dependable, locally controlled water supply, water recycling provides tremendous environmental benefits. By providing an additional source of water, recycling can help us find ways to reduce the diversion of water from sensitive ecosystems. Other benefits include fewer wastewater discharges and reducing and preventing pollution. Recycled water can also be used to create or enhance wetlands and riparian habitats.

Urban water reuse

Water scarcity in many regions means communities must make the most of their water resources by treating and reusing wastewater. Most recycled household water is from 'grey' wastewater sources, such as sinks, showers, washing machines and dishwashers, and more rarely from dirtier 'black' sewage water.

Often flowing through colour-coded pipes (the convention in some countries, including the USA is purple) so plumbers can distinguish it from other utility lines, recycled water can be used for a variety of mainly non-potable purposes, such as irrigation of golf courses, parks and green verges, to fill lakes and natural wetlands, as a firefighting reserve, for power station cooling towers, and even in artificial snow production for ski resorts.

Such reuse occurs when a community draws water from a river or reservoir that is also a receiver of wastewater (usually treated) from upstream communities. De facto reuse is quite common, particularly in dry periods, when natural water flows are reduced and wastewater makes up a larger proportion of the total flow.

The following describes a viable scheme of water re-use involving two neighbouring cities (Figure 14).Municipal wastewater from City 1 is treated and supplied via a separate distribution system for non-potable purposes, such as industrial cooling, agriculture, and landscape irrigation. A portion of the city's wastewater is further treated for potable water reuse. The highly treated water is used to recharge groundwater supplies, before it is withdrawn, disinfected, and blended with other drinking water supplies. Some of the treated wastewater effluent from City 1 is also discharged into a nearby river, where it mixes with river water and natural runoff. City 2, a downstream community, withdraws water from the river, treats it to drinking water standards, and uses the water for any purpose. Because the water drawn from the river contains a significant fraction of treated wastewater, this process is called de facto reuse.

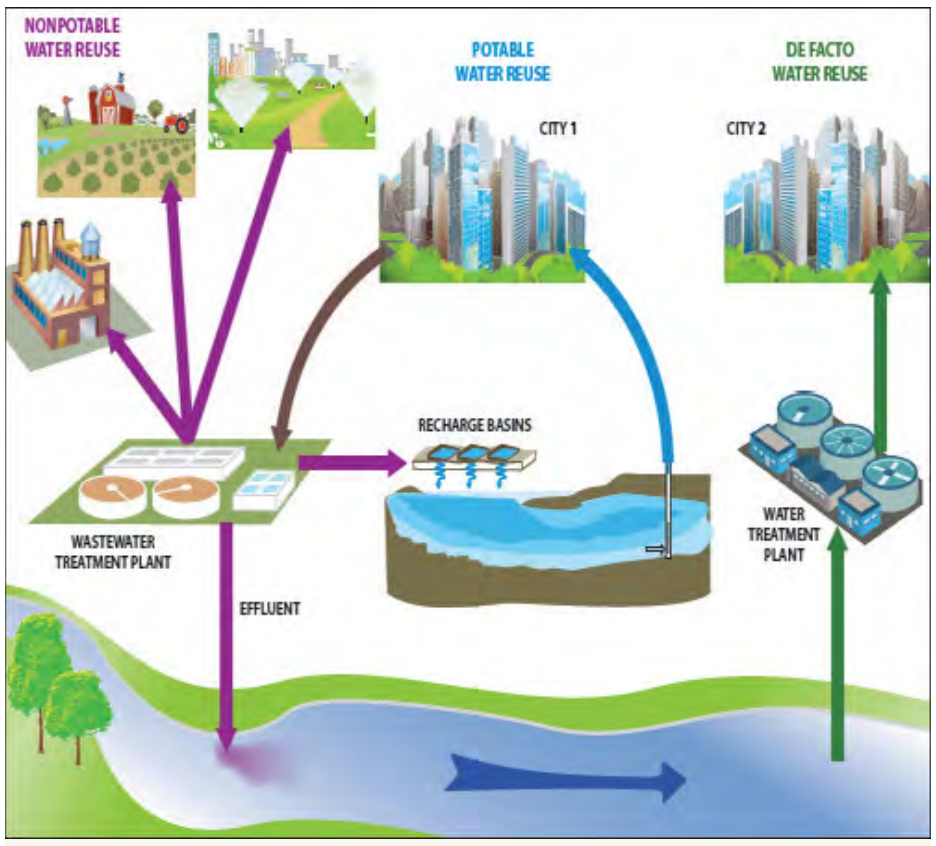


Figure 14: The process of treating wastewater and storing, distributing, and using reclaimed water in non-potable, potable, and de facto reuse. (Source: DMU)

Water
Reuse and Recycling

The DEMOWARE Project
Examples of successful water recycling

The following examples of water reuse stem from the European Research Project DEMOWARE which aims to demonstrate the successful application of reused treated wastewater for different purposes

Les Ferreres Aqueduct, also known as Pont del, is an ancient bridge, part of the Roman aqueduct built to supply water to the ancient city of Tarragona. © Rudy Mareel / Shutterstock.com

Example 1 - Recycling water for industrial reuse – Tarragona (Spain)

Water stress in specific areas can be mitigated by promoting industrial water reuse. The Tarragona site is located in the south of Catalonia, Spain, an area that is highly water stressed, with the water locked in existing water-use rights that hinder further economic growth in the region. Water reuse in an industrial park (a petrochemical complex) frees up existing water rights to meet future local demand, for municipal and tourism uses. In the industrial park, water is re-used for a number of non-potable industrial purposes, including for cooling and for the petrochemical industry.

The secondary effluent from two municipal wastewater treatment plants (WWTPs) (Vila-Seca and Tarragona) is treated and distributed to the end-users. Municipal effluent is treated using membrane technologies such as reverse-osmosis and ultrafiltration.

The reclaimed water produced is suitable for several uses in the petrochemical industry of Tarragona, resulting in a substantial positive impact on reducing total local water consumption and supporting further economic development in the local community.

Example 2 - Integrated water re-use in rural municipalities – Torre Marimon

Torre Marimon is a rural municipality located in Catalonia, Spain. Municipalities in rural areas face significantly different water management challenges compared to larger agglomerations and cities. Rural municipalities consume a large amount of water, especially for cleaning purposes, cooling and to provide animals with drinking water. At this demonstration site, the water reuse opportunities in rural communities were explored. The applications of water reuse include various uses on farms such as cleaning, cooling and drinking water for livestock. It also includes the use of reclaimed water for irrigation. The anaerobic membrane bioreactor technology used at this site offers a combination of membrane disinfection, biogas generation and the provision of nutrients. This technology allows agricultural wastes (vegetable waste, manure, etc.) and urban wastewater to be used to assist in the reclaiming of water and provision of biogas, while also helping to improve management strategies of agricultural wastes in a rural framework.

This site successfully demonstrates an innovative waste management strategy coupled with wastewater reclamation in rural zones.

City Hall and church, Sabadell, province Barcelona, Catalonia. © joan_bautista / Shutterstock.com

Architecture in Koksijde from the beach of the North Sea. © juergenhu / Shutterstock.com

Example 3 – Using water recycling for aquifer recharge for indirect potable use and to protect aquifers in coastal areas – El Port de la Selva (Spain) and Torreele (Belgium)

Demographic studies show that an increasing part of the European population is moving to cities and towards the coasts. Groundwater as a source of drinking water is of extremely high value. However, in coastal areas, aquifers are often vulnerable to seawater intrusion.

Touristic places along the coast have high seasonal variations in water demand for urban uses and drinking water purposes due to the population increase during the summer. In this case, recycling water can be a feasible solution. Recycled water can be used for recharging aquifers and irrigation. El Port de la Selva is a municipality located in the north-eastern part of Catalonia, Spain, on the Mediterranean coast. The municipal wastewater treatment plant effluent is further treated (filtered and disinfected) to meet the water quality required for several uses. The reclaimed water is used for irrigating parks, green areas and golf course irrigation. Nowadays, an innovative hybrid and low-cost/low-energy filtration/disinfection reuse scheme is being implemented for aquifer recharge. This increases the availability of groundwater for potable use, and includes seasonal storage and additional benefits such as seawater intrusion control. The reuse scheme is the first demonstration site in Europe that targets aquifer recharge for potable uses without using expensive double membrane systems. The reuse scheme consists of a soil-aquifer-treatment (SAT) system that relies on the favourable characteristics of the soil, subsoil and aquifers for further filtration of the infiltrated water to the aquifer. In this way, during summer, reclaimed water can be used directly for urban and golf course irrigation, and during winter for aquifer recharge.

The Torreele site is located on the Belgian North Sea coast. Since 2002, the effluent of the municipal WWTP of Wulpen has been reclaimed for indirect potable reuse after aquifer recharge of the dune aquifer of Saint André. This aquifer is used for groundwater extraction to produce potable water for nearby communities. The aquifer recharge using reclaimed water was implemented to prevent seawater intrusion and to increase the water table level in the dunes. The plant applies a double membrane process: ultrafiltration and reverse osmosis. There are considerable additional costs for handling the treatment concentrate so as to ensure a nutrient load discharge that is not excessive or damaging to the aquatic environment. This site is a good example of achieving public acceptance of water reuse, due to public communication since the beginning of the project, including via a visitor centre.

Example 4 – Reclaimed water for landscape irrigation and toilet flushing

A good example of the reuse of urban wastewater for non-potable uses is the water reuse scheme of the Olympic Park in London. The south-east of England is characterised by rapid population growth in a region of limited available water resources. The Old Ford Water Recycling Plant (WRP), located next to the Queen Elisabeth Olympic Park in London, is the UK's largest community wastewater recycling scheme. It was built in 2011 and was operational during the 2012 Olympic Games, and is owned and operated by Thames Water. The network provides water to the Olympic Park for toilet flushing, landscape irrigation and the topping up of rainwater harvesting systems. The WRP treats raw wastewater using a membrane bioreactor with ultrafiltration membranes, a granular activated carbon filtration and a disinfection system.
The Old Ford WRP scheme serves to demonstrate the sustainability of such schemes in terms of technology, resilience (contaminants removal, with special focus on microbiological pathogens), public awareness and acceptance of reclaimed water.

The London Aquatics Centre is located at Queen Elizabeth Olympic Park, in London, United Kingdom. A sporting complex built for the 2012 Summer Olympics © Paolo Grandi / Shutterstock.com

Water's collective memory or "What goes down the drain?"

Author(s) | ***Joana LOBO, Hubert CHASSAIGNE, Simona TAVAZZI, Helle SKEJO, Giulio MARIANI, Ine VANDECASTEELE and Bernd Manfred GAWLIK***

(Reviewed and amended by Peter EASTON)

Among the many fascinating properties of water, one is of particular interest when it comes to scientific research. It is the ability of water to create a memory of those chemicals with which it has been in contact. It sounds almost unbelievable, but modern analytical chemistry is capable of identifying even the slightest trace of a chemical pollutant in water.

To illustrate this ability, imagine that you throw a small sugar cube into an Olympic-size swimming pool. Determination of the concentration of sugar in this volume, if the pool was filled with pure water, is just a routine task in analytical chemistry. Throw the same amount of a chemical into three times this volume of water, equivalent to that of a modern oil tanker, and then you get an idea of what can be measured in water.

Are such small concentrations nothing to worry about? Some of the chemicals we are talking about can have an effect on wildlife and ecosystems at concentrations measured in "ng/L" (nanogrammes/litre or one billionth of a gramme per litre). What does this mean, using the example of the oil tanker? Let's assume that a sugar cube of 1 cm dimension weighs 5g. To achieve a concentration of 5 ng/L we need to dissolve it in 1 000 000 000 litres of water, or 1 000 000 m^3. That equals three to four times the volume of a typical super tanker. Obviously, at such low concentrations we would not expect, for example, an antibiotic to have any effect on us. But in some cases it can be harmful to wildlife.

This amazing, and at the same time worrying feature, also transforms our wastewater into something more than just dirty water to be cleaned up. Urban wastewater is not only a source of pollution, but its composition is a reflection of our chemical footprint in cities. In other words, many products we use and consume can be traced in our wastewater.

This applies not only to ingredients in household products, cosmetics, or pharmaceuticals, but also to society's dark side, for example, the abuse of drugs (recreational drugs). Thus, studying the chemical constituents of a city's wastewater can provide insights into societal behaviour.

This is the scope of some research projects, including the "iDRIP Project" (The National Academies, 2012), conducted by the European Commission's science and knowledge service, the Joint Research Centre (JRC) in partnership with several municipal waterworks. The iDRIP Project investigates the presence of the increasingly diverse range of pharmaceuticals and recreational drugs within the urban water cycle.

In recent years, concern about the impact of a "chemical cocktail" on human and public health have been increasing, and traditional legislation often does not address this topic. Hence, it is of pivotal importance to better understand the pathways, occurrences and synergetic effects of the chemicals used daily by citizens in order to better protect environmental and human health.

Performing extensive analyses of wastewater samples beyond the mere detection of single pollutants is a perfect way to gain access to such information. However, novel technologies to sample and extract the tremendously complex information in an economically viable way are urgently needed. The iDRIP project contributes to this endeavour.

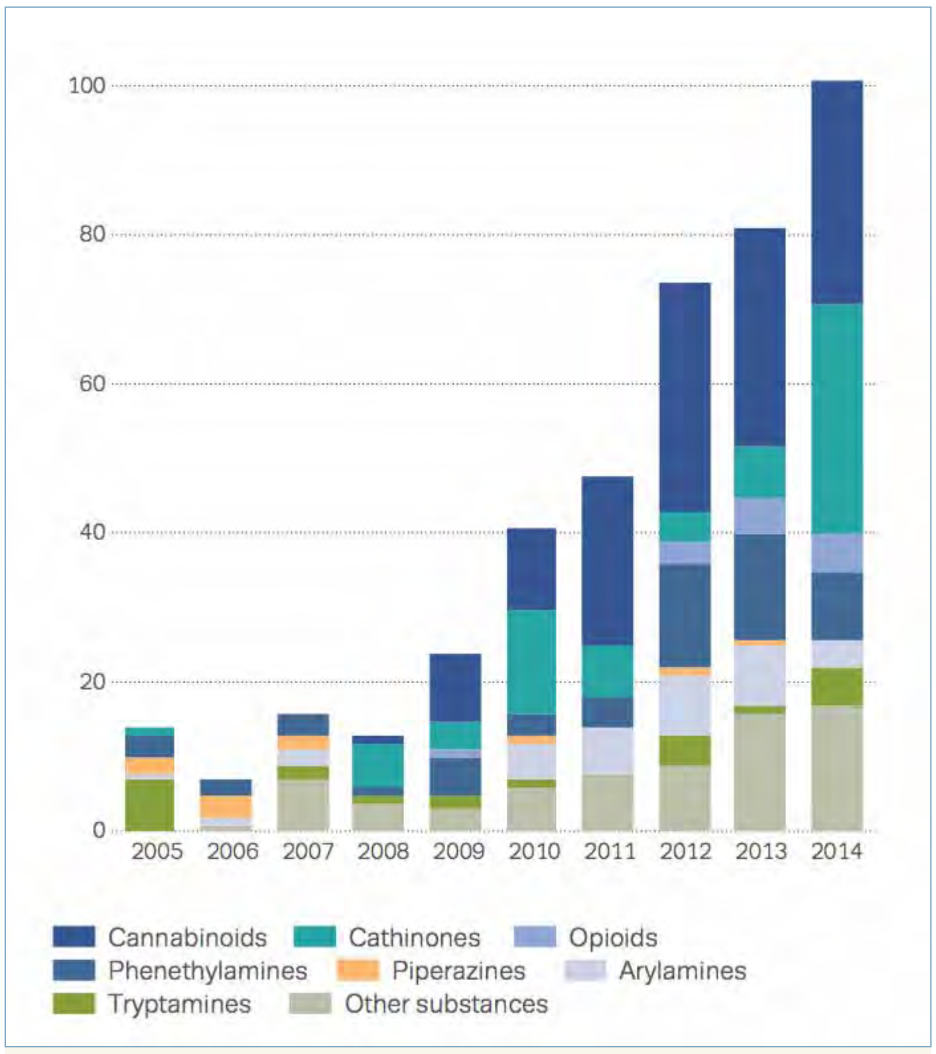


Figure 15: Number and categories of new psychoactive substances notified to the EU Early Warning System (Source: EMCDDA, 2015)

References:
EMCDDA, 2015. European Drug Report – Trends and developments. European Monitoring Centre for Drugs and Drug Addiction, European Union, Luxembourg.
The National Academies, 2012. Understanding water reuse. http://www.waterrf.org/PublicReportLibrary/4276.pdf [Last access: 23/01/2017]

In addition to compounds of emerging concern, another issue to be addressed is simple drug abuse. Recreational drugs are typically psychoactive drugs used to alter one's mental state in a way that modifies emotions, perceptions, and feelings without medical justification. While some of these drugs, such as cocaine, cannabis, or methamphetamine are well known and legally banned. The pharmaceutical industry generates New Psychoactive Substances (NPS) for legitimate purposes, but their misuse is a problem of increasing concern.

Figure 15 shows the number of seizures of NPS substances from 2005-2014 in the EU Member States (EMCDDA, 2015). Many such synthetic drugs mimic the effects of classic recreational and banned drugs. They are created by legitimate drugs manufacturers as legal alternatives to the classic drugs, by altering the chemical formula of a banned substance to a newer formulation not yet known to authorities and therefore not illegal. The hazardous health effects of such compounds are often not known before they are sold. Since they are readily available, frequently sold as research chemicals (Image 20) or herbal products, and cheaper than classic drugs, there are numerous associated intoxications and even deaths annually.

The JRC provides scientific and technical support for the rapid recognition of NPS substances and identification of unknown substances to the European Customs and the Directorate-General for Taxation and Customs Union (DG TAXUD), while also providing assistance in the identification of the priority substances to be regulated under European water legislation.

One of the challenges of this project is the extremely low concentration and heterogeneity of these substances in wastewater, making not only their analysis very challenging, but also posing a serious issue for wastewater treatment plants. In addition, many of the compounds degrade over time, so it is sometimes difficult to find them in a water sample.

With the support of the European Federation of National Associations of Water Services (EUREAU), the JRC is using a modern and straight forward sampling device, called the Mariani box (Image 21), which can concentrate up to 20 litres of wastewater onto a single pre-concentration disk. The analysis of wastewater allows for the monitoring of near real-time trends of contaminants, by measuring their levels and breakdown products excreted in urine. It is thus possible to map the spatial, and eventually temporal trends, in the population's drug consumption and production. The results of the project can be used to decide which new drugs require regulation, as well as to better design legislation to protect our water resources more effectively.

Image 20: Herbal NPS sample and research chemical. (Source: EC JRC, 2016)


Image 21: Mariani box for wastewater collection.(Source: EC JRC, 2016)

Understanding Water Footprints

Author(s) | ***Davy VANHAM***

What is an urban water footprint?

When we talk about water use in a city, we usually refer to drinking water distribution to our homes (but also schools, hospitals, offices) and resulting wastewater. Scientists refer in this context to the term “direct water use”.
Our hidden or “indirect water use”, which is used to produce the agricultural and industrial goods we consume is, however, much larger.
The water footprint of consumption of a city (or the urban water footprint) quantifies both the direct and indirect water use of a city. The direct water use refers to the municipal water use. The indirect water use refers to the amount of water used to produce the goods and services we consume.

The urban water footprint helps us to look at both direct and indirect water uses. It is also very useful to show citizens how they can take simple actions to reduce their water footprint, while at the same time, for instance, improving their health.

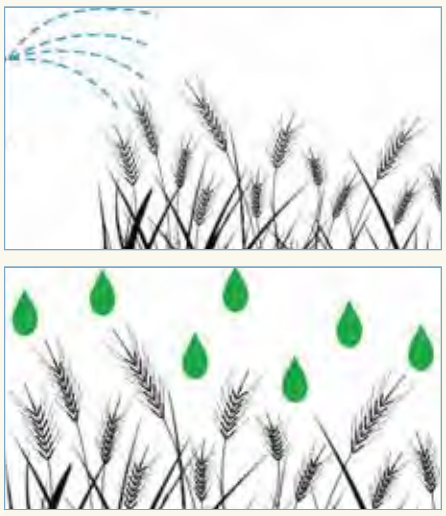


Figure 16: The water footprint has a green and blue water componnt

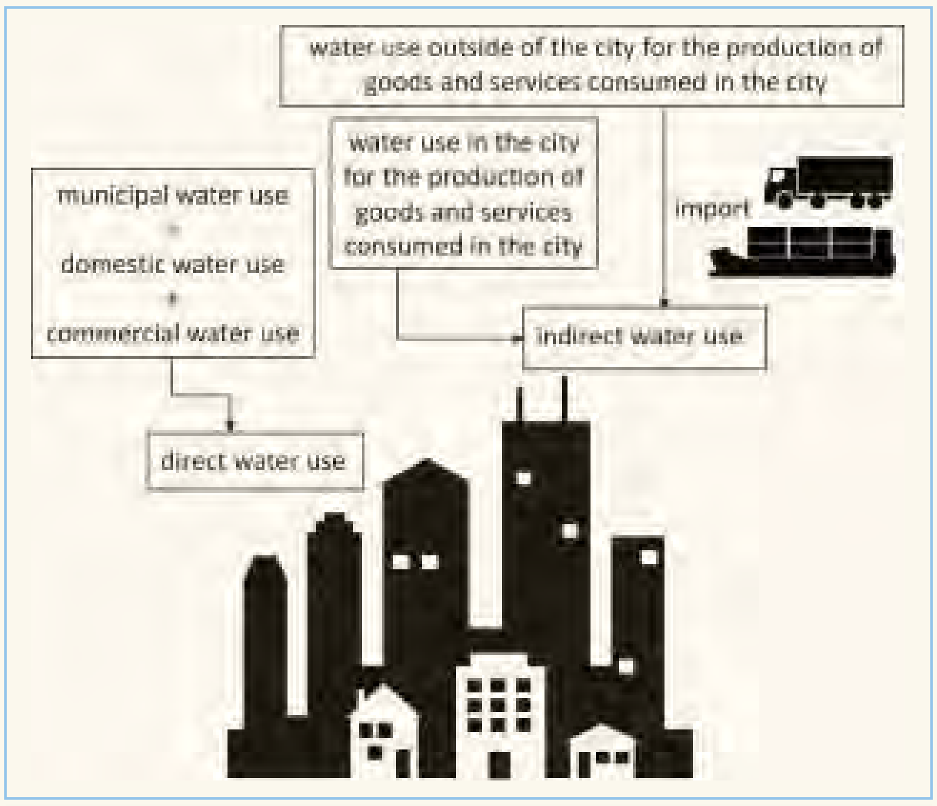


Figure 17: An urban water footprint is composed of the direct and indirect water use of a city.

How large is the water footprint of a city? The example of Bucharest.

In Bucharest, Romania, people have an average domestic water use of 162 litres per person per day (l/pers/d). This includes water for drinking, and all household uses.
On average, each citizen has a water footprint related to food consumption of an astonishing of 4 102 l/pers/d.

Figure 18: The urban water footprint of Bucharest is 4,102 l/pers/day. Direct water use is 162 l/pers/d. Indirect water use is thus 25 times greater!

Where do these agricultural products come from, and do they require a lot of water?

It requires a lot of water to produce the food that we consume. As an example, it takes about 100 litres of water to produce the tomatoes consumed in Europe, and 1 000 litres for 1 kg of wheat.
When we eat bread or pasta, we eat a lot of 'virtual' water. The highest amounts are required for meat, requiring up to 5 000-10 000 litres of water for 1 kg of beef!

Agriculture is the biggest water user worldwide. The production of our food can lead to water scarcity and water pollution. This happens in Europe, but also in other regions from which we import.

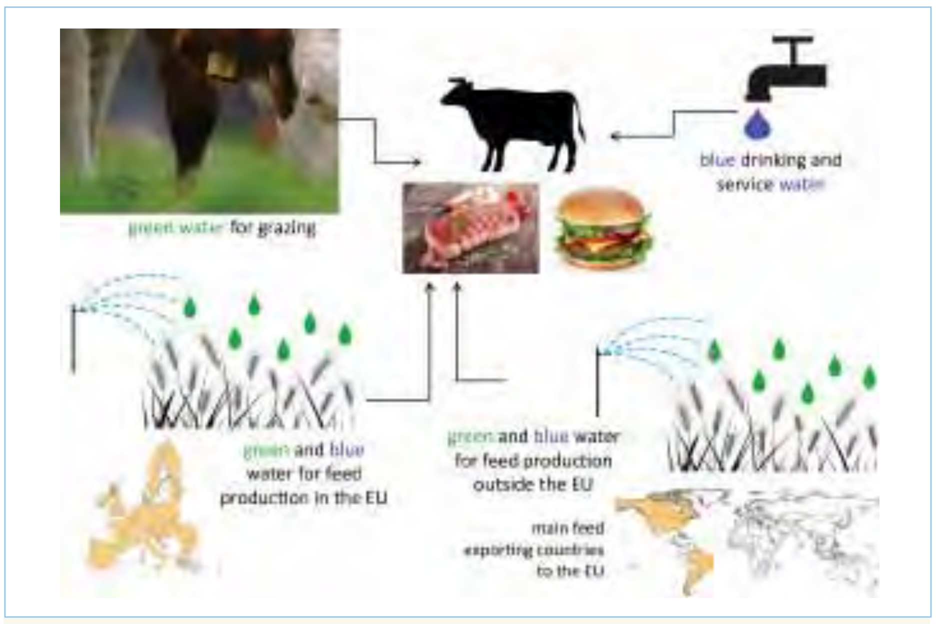


Figure 19: The production of the beef we consume requires a lot of water from different sources. Especially due to the large amounts of water required for feed production, the water footprint of beef can reach up to 5 000 to 10 000 litres per kg.

How can a Bucharest citizen reduce his/her water footprint?

Bucharest citizens can reduce their water footprint by shifting to a healthy diet and by reducing their food waste. They can reduce their consumption of sugar, meat, crop oils and milk products, which have large water footprints, and increase their consumption of fruit and vegetables, which are not so water intensive in their production.

A reduction of 15% (from 4 102 l/pers/day to 3 485 l/pers/d) is estimated for a 'healthy diet containing meat'. For a 'healthy pesco-vegetarian' diet (fish but no meat) the reduction is 29% (reduced to 2 896 l/pers/d) and for a fully vegetarian diet, it is reduced by 33% (to 2 764 l/pers/d).

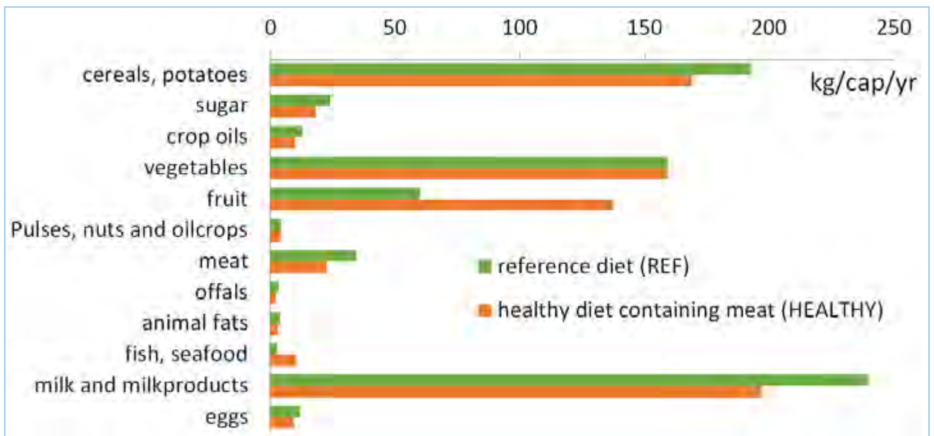


Figure 20: Intake of product groups for the current situation (reference period) and a healty diet containing meat.

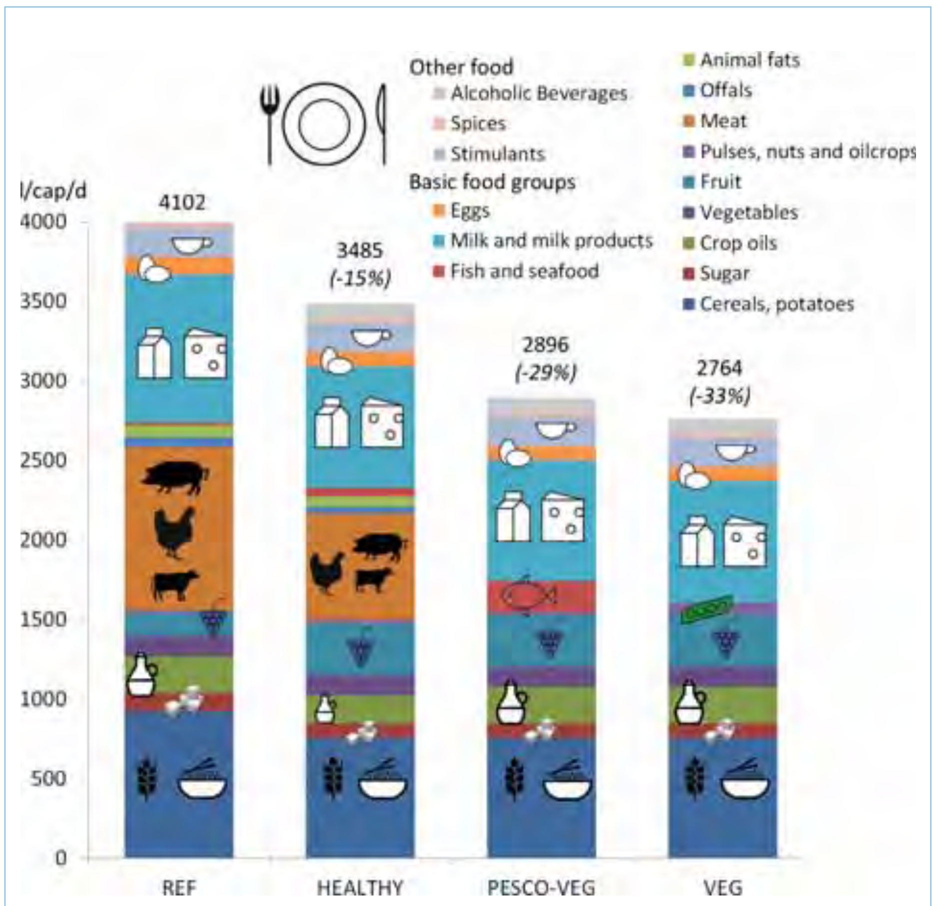


Figure 21: The urban water footprint of Bucharest for food products in four diets over: the reference period 1996-2005 (REF) a healthy diet as recommended by national Romanian dietary guidlines (Ghid pentru Alimentatia Sana-toasa) including meat 'healthy with meat' (HEALTHY), fish and vegetable (PESCO-VEG) and vegetarian diet (VEG).

EU citizens consume too much meat and sugar (with high water footprints), and not enough fruit and vegetables (lower water footprints). Thus, shifting to a healthier diet can reduce water footprint.
The average food waste of EU consumers is 123 kg per person per year. About 80% of this food waste is avoidable. This food waste occurs both at home, in restaurants and in supermarkets. By reducing our food waste, we also save water resources.
Certain non-edible agricultural products, such as cotton, also have large water footprints. By consciously buying fewer new clothes or making choices, water footprints can be reduced.
Many industrial products have a high water footprint. Paper is an example and, therefore, water footprints can be reduced by using less and recycling paper.

BLUE CITIES

42 BLUE CITIES

44-47 The BLUE S CITIES MANUAL

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128-133 A Global Perspective

Water bridges
(Wodne mosty)
Natalia Głowacka, 2016
Częstochowa, Poland

100 x 70
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas

USER MANUAL

HOW TO READ THE INFOGRAPHICS OF THE BLUESCITIES PROJECT
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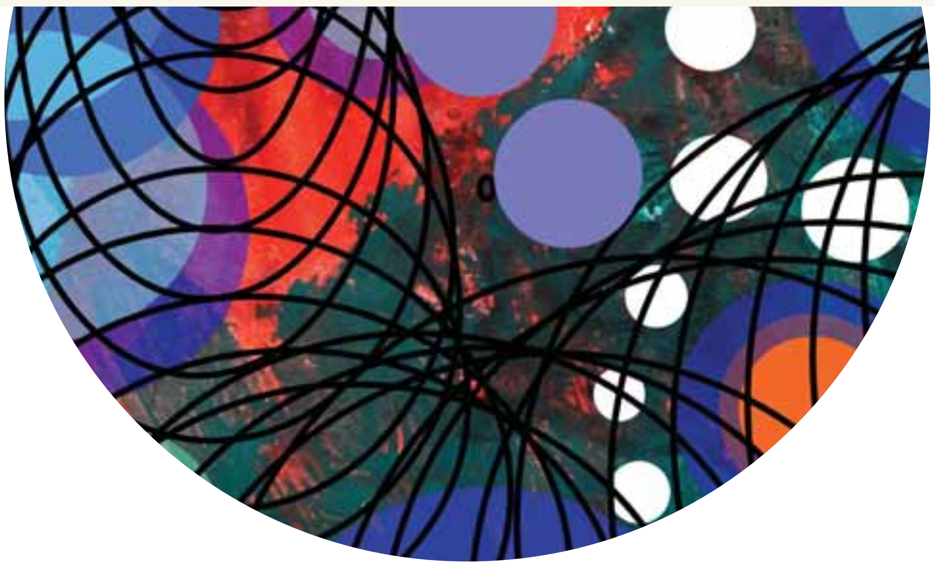

PAGE LAYOUT
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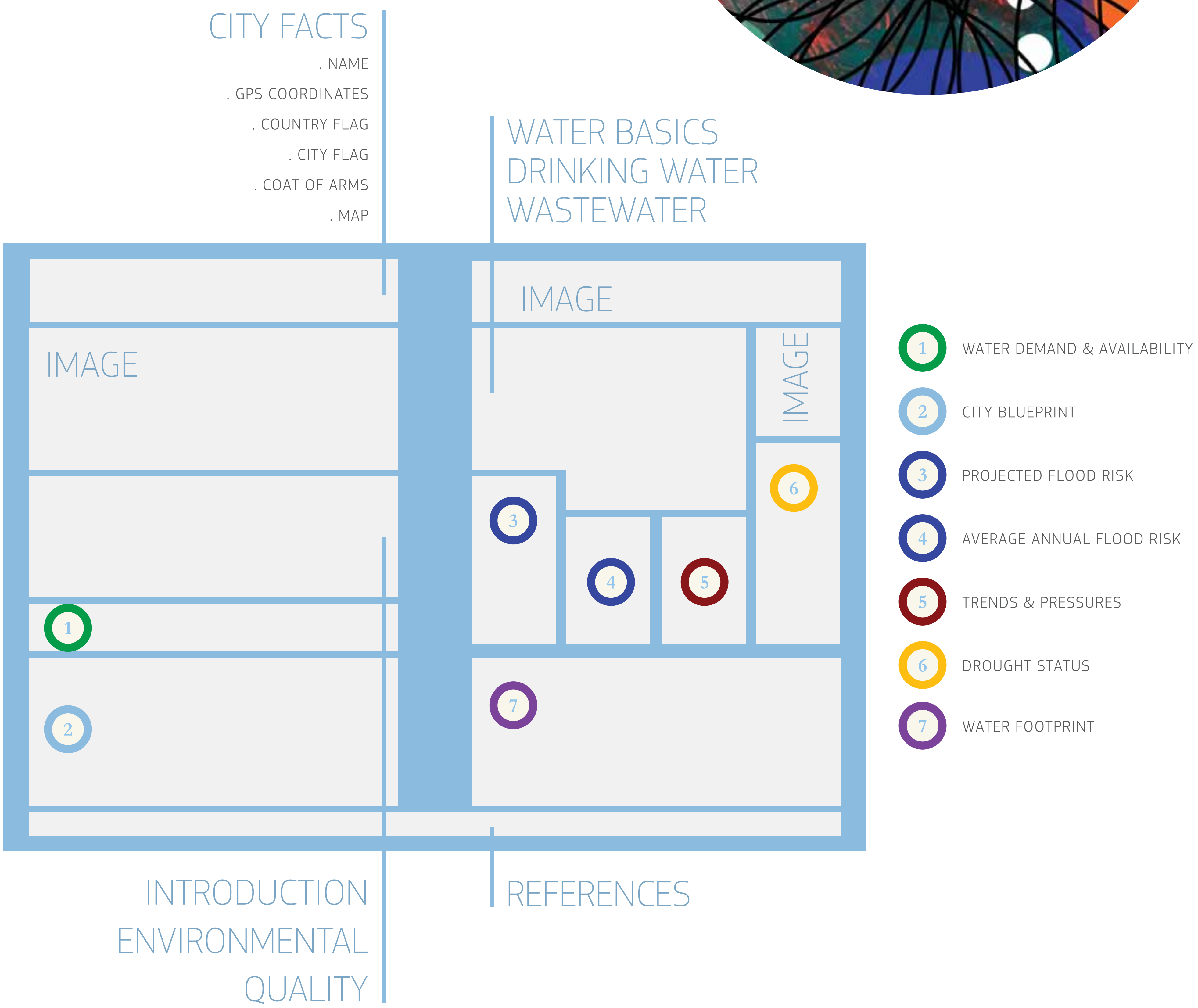
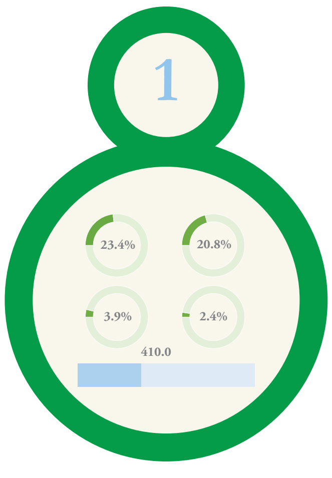
This manual explains, how to read the information on the following pages. Each of the graphic elements, are identified by numbers, and explanations about each graph and its meaning.





HOW TO READ THE WATER DEMAND & AVAILABILITY INFOGRAPHIC

The water demand & availability infographic combines water indicators selected to provide an overview on water availability and consumption in the selected cities. These indicators are derived from the output parameters of the LISFLOOD model. LISFLOOD is a computer model used to predict how rainfall and runoff will behave in a river basin or catchment area. LISFLOOD was developed by the Joint Research Centre (JRC) of the European Commission. Its objective is to be used in large and transnational catchments for a variety of applications, including flood forecasting, assessing the effects of river regulation measures, land-use change and climate change. A definition is given below for each indicator, represented by ring and bar charts to help the reader interpret the infographic.

The ring charts express a maximum percentage of 100%. When coloured red, a percentage greater than 100% is reached for the corresponding indicator, which may occur under particular circumstances. The bar charts express the indicator value from zero to the maximum value extracted from the model.

This infographic is produced for most cities included in this Atlas. However, for some cities, the LISFLOOD indicators are not available since they fall outside the new wider European-Mediterranean domain, for which the tool was developed.

The LISFLOOD water indicators depend on the defined Water Regions. They ideally consist of drinking water intake areas and/or management areas of the public water supply companies. Where this information is undefined, sub-river-basin regions were used, with hard country borders splitting them if appropriate.

The Water Exploitation Index (WEI) is a modelled estimate made at sub-river-basin scale and averaged for the period 1990-2012.

Soil Water Stress as percentage of days during the year: Expresses the percentage of days during a year that available soil moisture cannot fulfil the vegetation/crop demand.

WEI Demand: Water Exploitation Index (WEI) for demand (total water use): it defines the total water demand divided by the water available locally and flowing into the region from outside. Percentage values over 100% indicate that the city is using water at more than the renewable rate, and therefore needs to address efficiency and re-use issues. When the water demand and availability are well balanced (low percentage), the city shows a sustainable use of water resources from a total demand perspective.

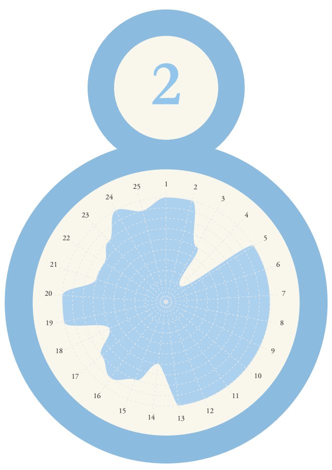
WEI Consumption: Water Exploitation Index (WEI) for consumption (net water use, which is total water use minus water returned to the local water cycle). This is expressed as the total net consumption divided by the water available locally and flowing into the region from outside. Percentage values over 40% and 100% indicate a significant and severe water stress condition, respectively. When the water consumption and availability are well balanced (low percentage), the city shows a sustainable use of water resources from a total consumption perspective.

Water Dependency: This indicator corresponds to the dependency of a city on external water resources (flowing into the region from outside) to meet its local water demand. When the value is zero, there is no water dependency, meaning the city does not receive any water from external/neighbouring regions.

Evapotranspiration difference: Corresponds to the difference between the potential evaporation (representing the evaporation rate if water is freely available) and the actual evapotranspiration for the region around the city. It is an indicator of the potential for crop failure without irrigation. When potential evaporation exceeds actual evapotranspiration, it indicates that irrigation is required to avoid crops becoming water stressed. ('Evapotranspiration' is the combination of 'evaporation' from water surfaces and of 'transpiration', the loss of water directly from the leaves and surface of vegetation.)

Scientific Reference:

De Roo A., Bisselink B., Beck H., Bernhard J., Burek P., Reynaud A., Pastori M., Lavalle C., Jacobs C., Baranzelli C., Zajac Z., Dosio A., 2016. Modelling water demand and availability scenarios for current and future land use and climate in the Sava River Basin. EUR 27701. Luxembourg (Luxembourg): Publications Office of the European Union.



HOW TO READ THE CITY BLUEPRINT INFOGRAPHIC

The City Blueprint infographic summarises at a glance how well a city CURRENTLY manages its urban water resources. This information is important to help identify priorities for further action and investment, but also to visualise strengths and weaknesses. The City Blueprint infographic is intended as a baseline against which future assessments can be benchmarked.

Indicator 1 – Secondary WWT Waste Water Treatment (WWT): This indicator shows the percentage of the city population that is connected to secondary wastewater treatment. Primary WWT removes the sludge, oil and grease from sewage. Secondary WWT combines physical removal of sediments and a biological process to remove suspended organic material.

Indicator 2 – Tertiary Waste Water Treatment (WWT): This indicator shows the percentage of the city population that is connected to tertiary WWT. Tertiary WWT provides a final treatment stage to further improve water quality by removing nutrients and pollutants, thereby avoiding the proliferation of algae in water bodies to which it is discharged (sea, rivers, lakes, wetlands, etc.).

Indicator 3 - Groundwater quality: This indicator represents the percentage of groundwater analyses showing 'good chemical status'. Groundwater is the water present under the Earth's surface. It discharges from springs, into wetlands and the beds of streams, rivers and lakes. In urban areas, it is sensitive to industrial pollution, and can transfer pollution to surface water by the routes mentioned.

Indicator 4 - Solid waste collected: This indicator reflects the amount of solid municipal waste collected in kilos, per person, per year compared to a benchmark of the best and worst collection rates. It takes into account households, small commercial activities, office buildings and institutions such as schools and government buildings and small businesses. Apart from the obvious reasons of health and the need to limit excessive plastic waste in rivers and oceans, solid waste is also a valuable resource if collected and processed properly. Benefits include the improvement of economic efficiency by good resource recovery, and the development of a market for the production and consumption of products from recycled materials. This in turn supports the development of sustainable employment and new business opportunities. The indicator reflects the amount of municipal waste collected in kilos, per person, per year.

Indicator 5 - Solid waste recycled: This indicator represents the percentage of solid municipal waste collected and recycled or composted, but excluding waste incinerated for energy, as this is also a sustainable activity. The recycling of solid waste reduces or eliminates some adverse environmental impacts. For example, it can help improve air and water quality and reduce greenhouse gas emissions. The long-term result is a more sustainable economy and a healthier natural environment.

Indicator 6 - Solid waste energy recovered: This indicator represents the percentage of solid municipal waste incinerated for energy production. Incineration is the process whereby solid organic wastes are burned to significantly reduce volume, create gaseous products and recover useful energy. The reduction in volume of solid waste by 20 to 30 percent is especially beneficial in countries with limited land available for landfill disposal. In a process called Waste-to-Energy (WtE), waste is also burned in furnaces or boilers to generate heat, steam or electricity, which helps reduce greenhouse gas emissions. However, as is the case with most fossil fuels, it is a controversial issue as the resulting emissions may contain organic compounds such as dioxins which may have negative environmental impacts.

Indicator 7 - Access to drinking water: This indicator shows the percentage of the urban population with access to safe drinking water. Access to drinking water is a basic human right recognised by the UN Millennium Development Goals. However, more than 780 million people still do not have access to safe and sufficient drinking water (UN, 2014).

Indicator 8 - Access to sanitation:
This indicator shows the percentage of the population with access to proper sanitation. Sanitation is the system for taking dirty water and other waste products away from buildings in order to protect people's health. Poor or absent sanitation infrastructure is a serious problem in many cities, especially in developing countries. The UN estimates that more than 2.5 billion people lack access to adequate sanitation (UN, 2014). This, combined with a lack of safe drinking water, results in millions of deaths each year from water-related illnesses.

Indicator 9 - Drinking water quality: This indicator represents the percentage of drinking water samples that comply with water quality regulations. Drinking water quality is usually controlled by local, regional or national legislation.

Indicator 10 - Nutrient recovery (from Wastewater Treatment): This indicator represents the percentage of the total wastewater which undergoes nutrient recovery. Nutrients are minerals and compounds which living things need to survive and grow. Nutrients such as nitrogen, potassium and phosphorus (essential components of fertilisers, and which are becoming increasingly scarce) are present in wastewater. If not removed or reduced by treatment, they can cause serious pollution in receiving water bodies. Therefore, it is beneficial to recover them from wastewater and sewage sludge (the solid waste component), to be used in fertilisers and to reduce water pollution.

Indicator 11 - Energy recovery: This Indicator represents the percentage of wastewater treated to recover energy. Wastewater sludge contains elements which can be converted into energy as burnable solids or gas (biomass). At least secondary wastewater treatment is necessary in order to obtain the sludge for energy recovery.

Indicator 12 - Sewage sludge recycling: This indicator represents the proportion of sewage sludge recycled to recover nutrients and/or energy. As mentioned for Indicators 10 and 11, sewage sludge can be used in agriculture or be converted into biomass to be burned in power plants for electricity generation. However, not all sludge is recycled. If it is heavily polluted with high levels of organic and inorganic contaminants, many countries prohibit its use in farming. This sludge may be converted into biomass or simply be incinerated in waste destruction installations.

Indicator 13 - Energy efficiency Waste Water Treatment (WWT): This indicator is a measure of the energy efficiency of the wastewater treatment in the city. An enormous amount of energy is used to sanitise, supply and treat water and wastewater. One of the principle subjects of any sustainable urban policy is the energy-water nexus, which highlights the connection between these two sectors. It has been calculated that the demand for energy to adequately treat water will have risen by 44% be tween the years 2006 and 2030. (IEA, 2009).

Therefore, the question of energy efficiency is just as vital as the production of renewable energies.

Indicator 14 – Average age sewer: This indicator compares the average age to an ideal maximum of 60 years. The older the system, the lower the score. There exists, at present, a serious situation concerning the lack of investment in renewal of sewer infrastructure. This is important because future projected climatic conditions will place greater pressure on drainage systems. The average age of the infrastructure is an indication of the financial commitment to regular system maintenance and replacement.

Indicator 15 - Operating cost recovery (which here is concerned exclusively with drinking water and sanitation services) is the total operational revenue divided by the annual operational costs. A higher profit margin gives a higher indicator score, because this signifies that the municipality has a stronger capability to improve its water infrastructure or react effectively to unforeseen circumstances such as water quality or pipe failure.

Indicator 16 - Water system leakages: This indicator compares the average leakage rate with a realistic, but undesirable maximum rate of 50% of water supplied. Leakage is defined as the difference between the volume of water put into the network at the drinking water plant and the total volume reaching customers' taps. Insufficient maintenance of the drinking water distribution network results in substantial water loss due to the poor physical conditions of the pipes in many municipalities.

Indicator 17 - Stormwater separation: This indicator shows the proportion of the wastewater system in which sanitary sewage and storm water flows are separated. There always exists a serious threat from extreme weather conditions, including storms. Often, the same drainage infrastructure carries both sewage and storm water, especially in the older parts of cities. A separate system is much preferred. In a combined system, extreme weather events can result in infrastructure overload, and sewer overflows into surface water, representing a major source of water pollution. Furthermore, the possibility of flooding is greater if storm water is not evacuated via a separate storm drainage network with adequately designed capacity.

Indicator 18 - Green space: This indicator reflects the percentage of the green area within a municipality. As defined by the EEA in 2012, a Green Space is an area of land within a municipality which consists of sports and leisure facilities, agricultural areas, semi-natural areas and wetlands, forests, gardens and parks. These areas are a vital component of any urban community as they counteract the heat which can be generated in cities (up to 10ºC higher than in surrounding areas), and air pollution, and are a social advantage and beneficial to the general well-being of citizens.

Indicator 19 - Climate adaptation: The indicator reflects the general activity with regards to urban climate issues including climate change adaptation measures.

Indicator 20 - Drinking water consumption: This indicator reflects the average drinking water consumption per person per year, comparing it to the best and worst examples in European cities. A higher water use per capita gives a lower score.

Indicator 21 - Climate-robust buildings: A measure of actions and policies for the creation of energy-efficient buildings, including those buildings which have been restored or reconverted in order to respond more adequately to such energy mechanisms as green roof creation, insulation, solar and geothermic technologies.

Indicator 22 – Management and action plans (of integrated water resources management): A measure of the application of the concept of Integrated Water Resources Management (IWRM) in the city. IWRM is a process which promotes the coordinated development of the management of water, land and related resources in order to maximise the economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP).

Indicator 23 - Public participation (in voluntary organisations and societies of all types): This indicator is an estimate of how many citizens of the municipality participate voluntarily in organisations, societies and clubs of all description. This serves as an indication of a community's willingness to become actively involved in social issues such as those related to water and climate change adaptation. It cannot, however, be considered as a definitive measurement.

Indicator 24 - Water-efficiency measures: An indication of the application of water-efficiency measures by the range of water users across the city. The measures in question include plans, procedures and their implementation to improve the efficiency of water usage by, for example, water-saving measures in taps, toilets, showers and baths, water-efficient design, or attempts to raise awareness.

Indicator 25 – Attractiveness (the use of water elements in the creation of the urban landscape): A measure of how surface-water features are contributing to the urban landscape of the city and well-being of its inhabitants. Water is, without question, an added value to any city's physical appearance. For example, water is a dominant feature in some cities that attract large numbers of tourists, such as Venice, Hamburg and Amsterdam. The property prices in the vicinity of rivers, canals and harbours are often much higher than in other parts of the city.

Scientific Reference:

The infographic is based on a scientific concept published by Koop and van Leeuwen. The interested scientific reader is pointed to the following (non-exhaustive) list of peer-reviewed publications:

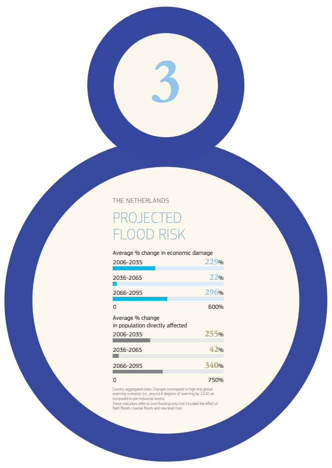
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Van Leeuwen C.J., Koop S.H.A., Sjerps R.M.A., 2016. City Blueprints: baseline assessments of water management and climate change in 45 cities. Environment, Development and Sustainability, 18, 1113–1128

Van Leeuwen C.J., Frijns J., van Wezel A., van de Ven F.H.M., 2012. City Blueprints: 24 indicators to assess the sustainability of the urban water cycle. Water Resources Management, 26, 2177–2197

While the papers describe the scientific context, the underlying data have been retrieved from publicly accessible databases and collections, as referenced here:

Koop S.H.A., Van Leeuwen C.J., 2015. Application of the Improved City Blueprint Framework in 45 municipalities and regions. BlueSCities Deliverable D2.2. Coordination and Support Action 642354 of the European Commission (KWR report 2015.025), 130 pp. Available at: http://www.bluescities.eu/wp-content/uploads/2015/09/D-2-2-BlueSCities-642354-Final-03-08-2015.pdf [Last access: 17 January 2017]



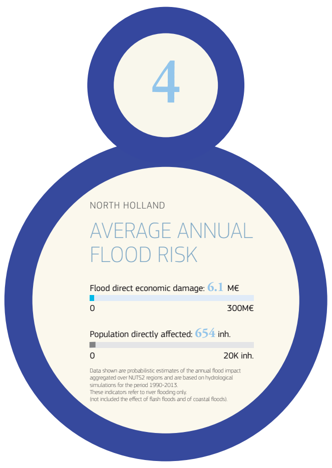
HOW TO READ THE PROJECTED FLOOD RISK INFOGRAPHIC

The projected flood risk assessment offers projections on flood risk, assuming no global reduction in carbon dioxide emissions and projected extreme global warming of around 4°C by 2100 (compared to the pre-industrial level). The indicator is useful to better understand the importance of investing in a city's resilience to floods.

The data shown are aggregated over countries, not cities. Changes are estimated in three future time windows of 30 years: 2006-2035 (centred on 2020); 2036-2065 (centred on 2050); and 2066-2095 (centred on 2080). These indicators refer to river flooding only (not including flash floods, coastal floods and sea-level rise). The first graph represents the average percentage change in economic damage. The second graph represents the average percentage change in population directly affected by flood risk.

Scientific Reference:

Alfieri L., Feyen L., Dottori F., Bianchi A., 2015. Ensemble flood risk assessment in Europe under high end climate scenarios. Global Environmental Change, 35, 199–212



HOW TO READ THE AVERAGE ANNUAL FLOOD RISK INFOGRAPHIC

The term 'flood risk' is an expression of the combination of the likelihood of a flood event occuring and the seriousness of its impacts, which can include property damage and loss of life. For example, a very damaging flood that is likely to occur only once in 1 000 years is 'low risk', whereas a flood that could damage and flood buildings and is likely to occur once every five years is 'high risk'. The greatest risk, of course, is a very damaging flood that is likely to occur often.

Scientifically speaking, "Flood risk is the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event" (EU Floods Directive, European Commission, 2007).

The infographic "Average Annual Flood Risk" shows two bars. The first one 'Flood direct economic damage' represents the cost to repair damage, but also other economic side-effects such as loss of income by affected citizens and businesses. It covers the period 1990 to 2013.

The second bar, 'Population directly affected' represents the number of citizens impacted, themselves and/or their property, for the same 1990 to 2013 period.

These data are based on simulations and scientific models that consider complex information on rainfall, climate and other influencing factors in a defined area, the NUTS2 regions. These are administrative regions defined by the European Commission, representing a population of 800,000 to 3 million. The indicators refer to river flooding only, and do not include flash floods or coastal floods.

Scientific Reference:

Alfieri L., Feyen L., Salamon P., Thielen J., Bianchi A., Dottori F., Burek P., 2016. Modelling the socio-economic impact of river floods in Europe. Nat. Hazards Earth Syst. Sci., 16, 1401-1411

HOW TO READ THE TRENDS & PRESSURES INFOGRAPHIC

Each city has its own social, financial and environmental characteristics and conditions, which, in turn, impact on its approach to managing its water systems and related infrastructure. The infographic reflects these boundary conditions by grouping them into three categories: social, environmental and financial. The lower the score for each indicator, the better the boundary conditions of the city.

Urbanisation Rate: Describes how fast the city is growing based on the rate of increase in the resident population.

Burden of Disease: This indicator shows the impact of a health problem as measured by financial cost, mortality, morbidity, or other indicators. Here it is based on the WHO global burden of disease (GBD) measure using the disability-adjusted-life-year (DALY), a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death.

Education Rate: Education rate is expressed as the percentage of children completing primary education, considered representative of the human capital in the city.

Water Scarcity: A measure of whether the city's water consumption is sustainable or exceeds the available renewable water resources.

Flood Risk: A measure of the proportion of a city's inhabitants subject to river or coastal flood risk, often increasing with intensive urbanisation.

Water Quality: A measure of the water quality and aquatic biodiversity in surface water according to the water quality index (Yale University) and the European Water Framework Directive for good ecological status.

Heat Risk: A proxy for the urban heat island effect which describes increased urban temperatures compared to a city's rural surroundings. The temperature difference can be up to 10°C or more. The expected number and frequency of heat waves are considered together with mitigating measures of urban water and vegetated surfaces to reduce the amplified urban temperature.

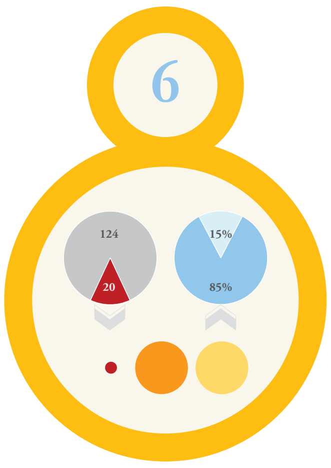
Economic Pressure: Based on the Gross Domestic Product (GDP) per capita.

Unemployment Rate: The unemployment rate (%) is an important measure of the trend of economic development and tax income, the latter being the primary source for financing water supply infrastructure in many cities.

Poverty Rate: Based on the percentage of the population with less than USD$2/day spending power.

Inflation Rate: Provides a measure of the potential to retain reserves for future investments on infrastructure for integrated water resource management.

Scientific Reference:
The infographic is based on a scientific concept described by Koop and Van Leeuwen in the context of the BlueSCities Project and is publicly available for download:
Koop S.H.A., Van Leeuwen C.J., 2015. Application of the Improved City Blueprint Framework in 45 municipalities and regions. BlueSCities Deliverable D2.2. Coordination and Support Action 642354 of the European Commission (KWR report 2015.025), 130 pp. Available at: http://www.bluescities.eu/wp-content/uploads/2015/09/D-2-2-BlueSCities-642354-Final-03-08-2015.pdf [Last access: 17 January 2017]



HOW TO READ THE DROUGHT STATUS INFOGRAPHIC

INTRODUCTION

The principal cause of a drought is a prolonged period of unusually low or absent rainfall. The impacts can be amplified by other factors, such as high temperature or a poor capacity of soil to retain water (low soil moisture levels). When the lack of rainfall leads to such low soil moisture content that plants can no longer satisfy their need for water and start to suffer, it can be described as an agricultural drought.

Following this idea of multiple drought factors, scientists have developed an indicator based on weather and climate observations, and satellite data. This combined index is used to map areas affected by drought. It can also be used to show which areas are more likely to experience drought. This is very useful to help plan for actions or policies to prevent or mitigate the impacts of drought.

The Combined Drought Indicator (CDI) is based on the three main indices of the European Drought Observatory (EDO): SPI, pF and fAPAR, as explained below.

. The Standardized Precipitation Index (SPI-n) (McKee et al., 1993) is a statistical indicator. It compares the total precipitation received at a particular location during a specific time period with the long-term rainfall for the same period of time at that location. It is one of the more common drought indicators.

. Soil moisture (pF) is an important variable in hydrologic, climatologic, biologic, and ecological processes because it plays a crucial role in the interactions between the atmosphere and land surface.

. The Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) is a measure of the fraction of sunlight (or better solar energy) which is absorbed by the vegetation. It is proposed as a drought indicator due to its sensitivity to vegetation stress (Gobron et al., 2005 and 2007). Droughts can cause a reduction in the vegetation growth rate, which is affected by changes either in the solar interception of the plant or in the light-use efficiency.

The CDI provides assessments for Europe for successive 10 day periods.

HOW TO READ
THE DROUGHT STATUS INFOGRAPHIC

The data shown in the Drought Status infographic for each city are computed for 10-day periods from 2012 to 2015. This covers 144 periods, giving a total of 1 440 days. If no drought was observed in a 10-day period, it is defined as 'normal'; if a drought was observed, then it defined as a 'stress incident'. This is not on its own an alarming sign, because it is normal to have in some regions, in summer, extended periods of no rain when plants may experience short-term stress. This means there also needs to be an assessment of whether plant stress is temporary or irreversible. An arrow on the infographic indicates this classification of the stress incidents.

The classification scheme is based on three drought impact levels: a first early warning (WATCH), an acute warning (WARNING) and an alarm (ALERT). These three levels are represented in the infographic by the three circles at the bottom:

. WATCH (yellow circle)
. WARNING (orange circle)
. ALERT (red circle)

The arrow on the right points to a second pie chart representing two additional levels, which identify the stages of the vegetation recovery process after stress incidents:

. Partial recovery
. Full recovery

What does this mean in practice? A partial recovery means that part of the city's vegetation has been damaged permanently because of drought. This is all the more remarkable if one considers that such damage occurs also in cities where we would not expect it, for example in northern Europe. The indicator is therefore useful for describing the impacts of a changing climate.

Description of single elements

WATCH: A significant precipitation shortage is observed.

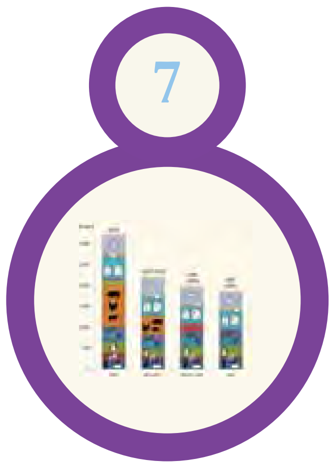
WARNING: A precipitation shortage progresses to a low soil-moisture anomaly.

ALERT: The precipitation shortage and low soil-moisture anomaly are accompanied by a stressed vegetation condition.

PARTIAL RECOVERY: After a drought event, the meteorological conditions have recovered to normal but not the vegetation conditions.

FULL RECOVERY: Meteorological and vegetation conditions have returned to normal following a drought event.

Scientific Reference:
McKee T.B., Doesken N.J., Kleist J., 1993. The relationship of drought frequency and duration of time scales. Eighth Conference on Applied Climatology, American Meteorological Society, Jan17-23, 1993, Anaheim CA, pp.179-186.



HOW TO READ THE WATER FOOTPRINT INFOGRAPHIC

The water footprint of a city, or more simply "the urban water footprint", quantifies both the direct and indirect water use of a city and its citizens. The direct water use refers to the municipal water use, such as the tap water delivered to a house. The indirect water use refers to the amount of water used to produce the goods and services consumed within the city. This information is not directly visible, and is sometimes referred to as 'virtual water'. It contains, for instance, a measure of the amount of water used in the production, transport and processing of the food consumed by citizens. In the infographic, one sees that, in particular, the amount of meat we choose to eat can have a considerable impact on the water footprint.

The graphic distinguishes four types of diet:

REF: The reference diet, representing a typical average annual diet for the city, based on 10 years of dietary information.

HEALTHY: Representing a healthy diet containing less meat, based on recent nutrition recommendations valid for the city.

PESCO-VEG: Representing a healthy fish & vegetable diet based on similar recommendations.

VEG: Representing a healthy vegetarian diet based on similar recommendations.

The scientific details and findings are cited at the bottom of each page. Water footprint information is provided for the principal food groups and constituents.

Scientific Reference:
The infographic is based on a scientific concept developed by Hoekstra et al. and applied to cities by Vanham et al.

A.Y. Hoekstra, A.K. Chapagain, M.M. Aldaya, M.M. Mekonnen.
Hoekstra A.Y., Chapagain A.K., Aldaya M.M., Mekonnen M.M., 2011. The Water Footprint Assessment Manual: Setting the Global Standard. Earthscan, London, UK.
Vanham D., Bidoglio G., 2013. A review on the indicator water footprint for the EU28. Ecological Indicators, 26, 61–75
Vanham D., Bidoglio G., 2014. The water footprint of Milan. Water Science & Technology, 69, 789–795
Vanham D., Hoekstra A.Y., Bidoglio G., 2013. Potential water saving through changes in European diets. Environment International, 61, 45–56
Vanham D., Mekonnen M.M., Hoekstra A.Y., 2013. The water footprint of the EU for different diets. Ecological Indicators, 32, 1–8.
Vanham D., Bouraoui F., Leip A., Grizzetti B., Bidoglio G., 2015. Lost water and nitrogen resources due to EU consumer food waste. Environmental Research Letters, 10, 084008.
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M.,2016. Water consumption related to different diets in Mediterranean cities. Science of The Total Environment, 573, 96–105
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: the example of Dutch cities. Science of The Total Environment, 565, 232–239
Vanham D., 2012. A holistic water balance of Austria—How does the quantitative proportion of urban water requirements relate to other users? Water Science & Technology, 66, 549–555
Vanham D., 2016. Does the water footprint concept provide relevant information to address the water-food-energy-ecosystem nexus? Ecosystem Services, 17, 298–307.
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 4, 119–129

BLUE CITIES

The following pages present information on a series of 40 cities, which have been assessed and described as regards their water. The information displayed is not meant to be a comparison between these cities, but an expression of the cities' awareness for water. The information highlights a particular challenge a city may face or which measures a city takes to improve urban water management. It is in any case an invitation to the citizen to become interested in water.

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62-63 . Bucharest
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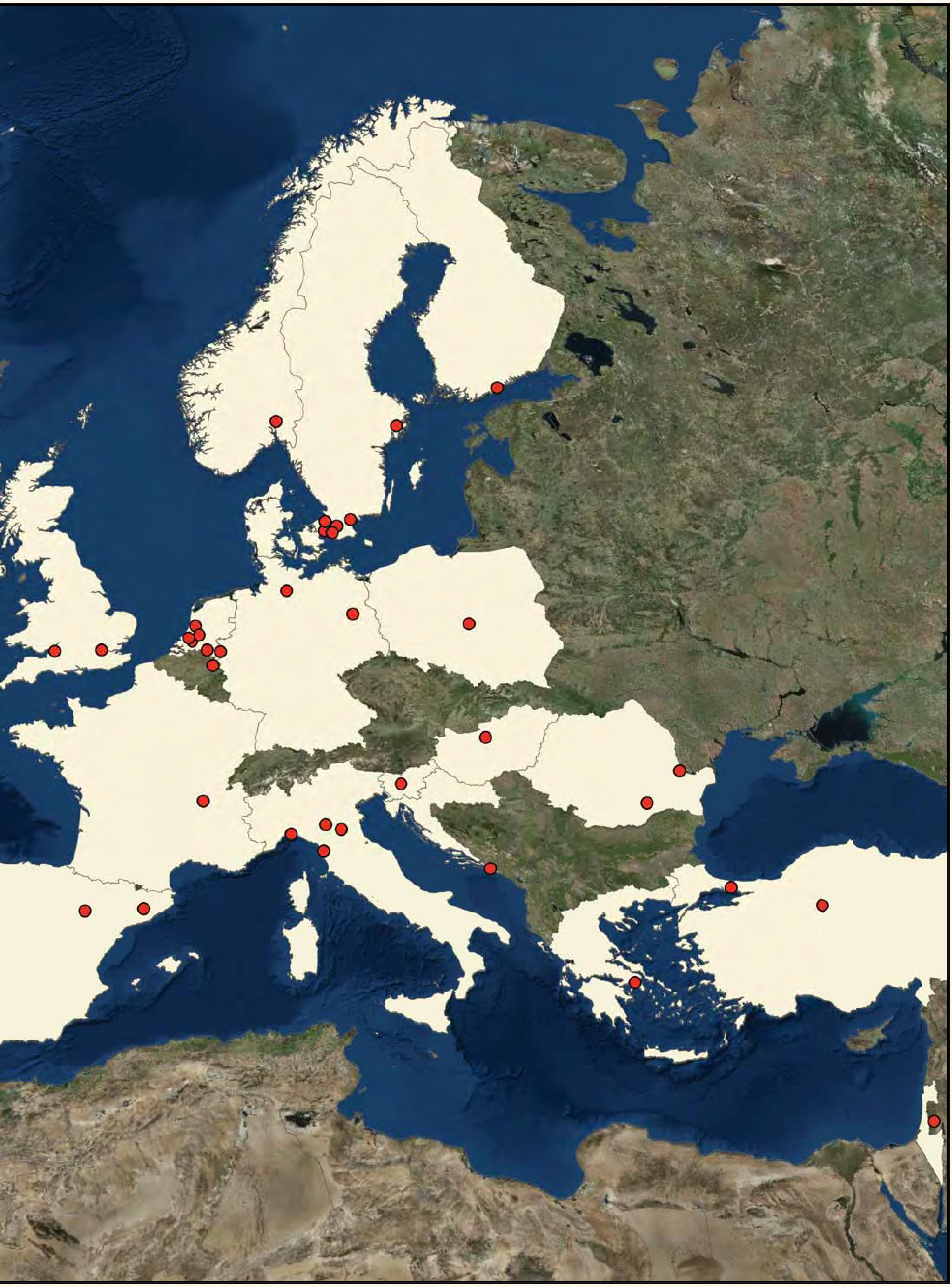
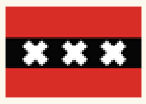


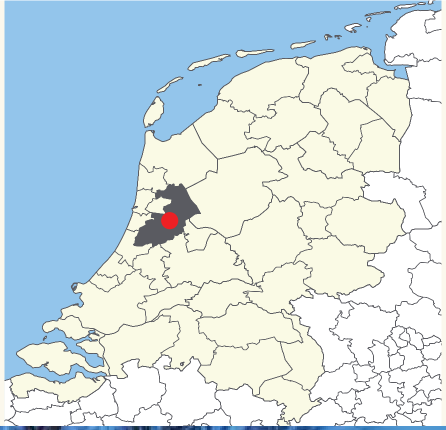
Amsterdam

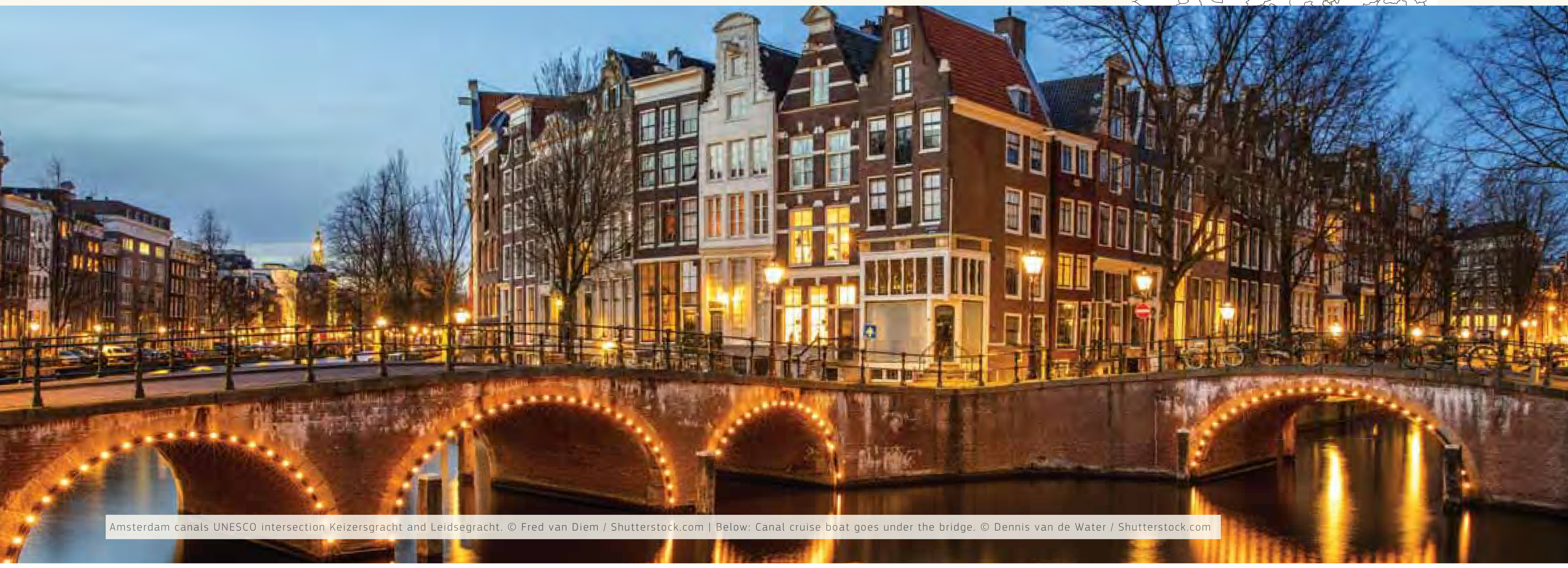
52°22′26″ N | 4°53′22″ E *Country: The Netherlands, Region: Amsterdam*


National Flag


City Flag


Coat of Arms




Amsterdam canals UNESCO intersection Keizersgracht and Leidsegracht. © Fred van Diem / Shutterstock.com | Below: Canal cruise boat goes under the bridge. © Dennis van de Water / Shutterstock.com

AMSTERDAM

Amsterdam is the capital and largest city of the Netherlands, with a population of around 800 000, rising to 1 600 000 for the wider metropolitan area. It also receives over 3.5 million foreign visitors a year. It is an important European financial centre, and its stock exchange is the oldest in the world. The municipality pays great attention to the quality of life and has an ambitious climate and energy programme. Amsterdam and water are intimately connected; the name of the city refers to a dam on the Amstel river, which terminates in the celebrated historic canals of the old city centre. Amsterdam has an oceanic climate, strongly influenced by its proximity to the North Sea to the west, with prevailing westerly winds. Both winters and summers are generally mild, although occasionally quite cool.

ENVIRONMENTAL QUALITY

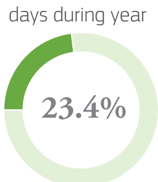
Amsterdam aims to be a competitive and sustainable metropolis in the face of economic, demographic and climate challenges. With a vision of sustainable progress, construction and energy, its target is to be one of the world's most sustainable cities by 2020. Amsterdam has always taken a lead in national and international water management. Its water company was the first to deliver piped water in the country (1853) and the first in the modern developed world to not use chlorine to treat surface water. In 2006 the various urban water-related services were combined as the country's first water cycle company called Waternet, an approach which has proven to be highly beneficial.

Resident population (x 1 000)	811
Population density (inhabitants/km²)	3 698
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

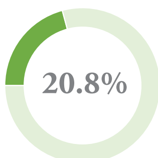
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

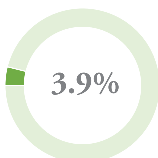
% SOIL WATER STRESS days during year



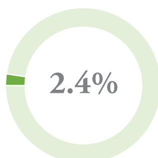
W.E.I. DEMAND



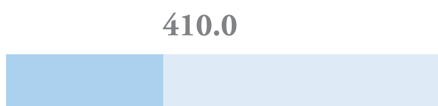
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



AMSTERDAM

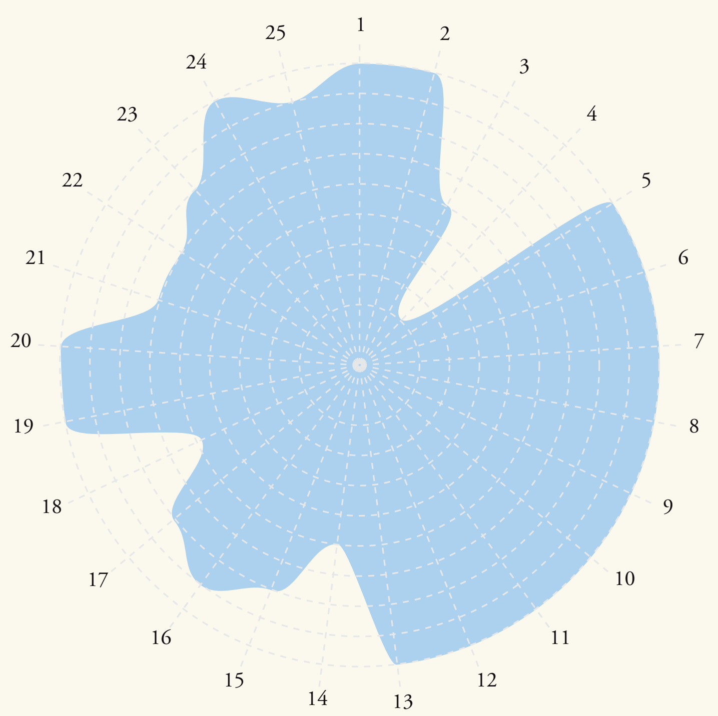
CITY BLUEPRINT ©

Amsterdam is a leading city, especially with regard to wastewater treatment and climate change adaptation. However, there is room for improvement, for example in reducing solid waste production.

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **8.3**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	6.1
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	9.9
11	Energy Recovery	9.9
12	Sewage Sludge Recycling	9.9
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	6.4
15	Operation Cost Recovery	8.5
16	Water System Leakages	8.9
17	Stormwater Separation	8.3
18	Green Space	5.9
19	Climate Adaptation	10.0
20	Drinking Water Consumption	9.8
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.0
23	Public Participation	8.1
24	Water Efficiency Measures	10.0
25	Attractiveness	9.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., Sjerps R.M.A., 2015. The City Blueprint of Amsterdam: An assessment of integrated water resources management in the capital of the Netherlands. Water Science and Technology. Water Supply, 15, 404-410
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Canals of Amsterdam at night. Amsterdam is the most populous city of the Netherlands © S-F / Shutterstock.com

WATER BASICS

Amsterdam lies two metres below sea level. The surrounding land is flat, being formed of large polders (low-lying land protected by dykes). A manmade forest, Amsterdamse Bos, is situated south-west of the city. Amsterdam is connected to the North Sea through the long North Sea Canal, and is itself home to more than one hundred kilometres of canals, most of which are navigable.

Annual average rainfall (mm)	810
Daily average air temperature (°C)	10.0
% of blue and green area	34.9
% of soil sealed	45.4
% flooded by 1-m sea level-rise	94.2
% flooded by 1-m river level-rise	69.7

DRINKING WATER

Amsterdam's drinking water originates from lowland surface water (88%) and groundwater (12%), achieving 100% population coverage. The per capita water consumption of 50 m^3 per person per year, is among the lowest in Europe. The quality of supplied water is excellent. The water supply network totals 3 098 km, with an average age of 26 years. The number of pipe failures is very low (0.839 per 100 km) as are the water losses (5.4%).

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	5.4
Drinking water consumption (m^3/cap/year)	49.6
Drinking water consumption (litres/cap/day)	138

WASTEWATER

Amsterdam has both combined sewers and separate sanitary sewers and stormwater sewers. The wastewater energy costs are €1.1 million per year, including energy recovery from wastewater, but with no nutrient recovery. A national law forbids the application of sewage sludge in agriculture due to heavy metals and other persistent pollutants, so all sludge is thermally treated.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater treated with nutrient-recovering techniques	100
% wastewater treated with energy-recovering techniques	100
Average age of sewer (years)	28
% sewer with separated stormwater and sanitary water	82.9

Hipster Bike on Bridge.
© Iulian Dragomir / Shutterstock.com

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 229%

2036-2065 22%

2066-2095 296%

0 600%

Average % change in population directly affected

2006-2035 255%

2036-2065 42%

2066-2095 340%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

NORTH HOLLAND

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 6.1 M€

0 300M€

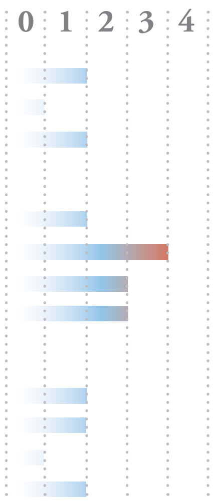
Population directly affected: 654 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

1.2



Social
- Urbanisation Rate
- Burden of Disease
- Education Rate

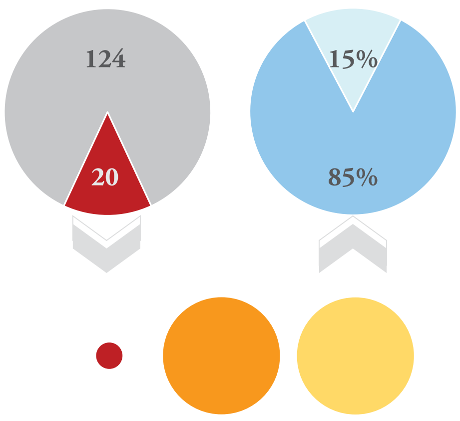
Environmental
- Water Scarcity
- Flood Risk
- Water Quality
- Heat Risk

Financial
- Economic Pressure
- Unemployment Rate
- Poverty Rate
- Inflation Rate

Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



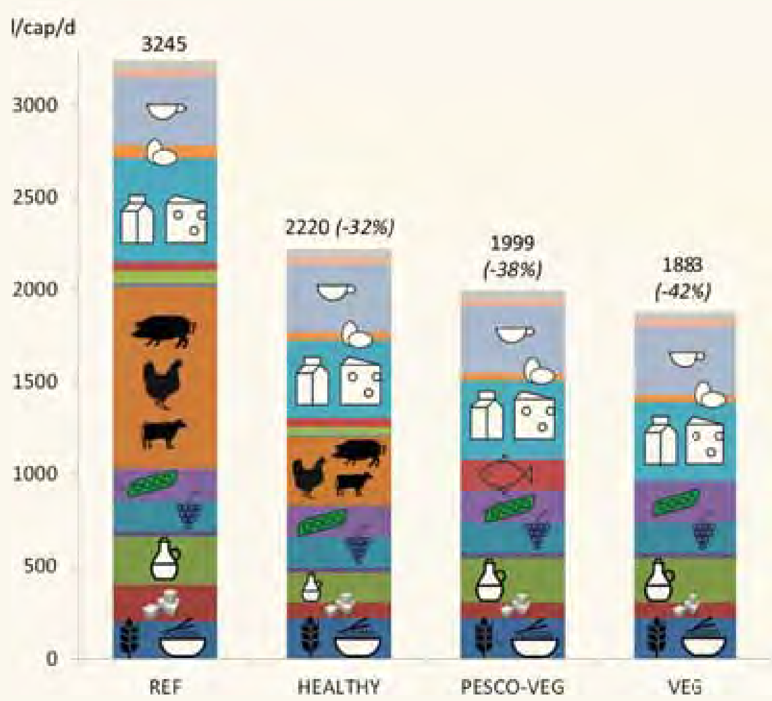
ALERT: 2 WARNING: 9 WATCH: 9

Stress incidents for drought level

AMSTERDAM

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Amsterdam. Four dietary scenarios are shown. The current diet of the inhabitants of Amsterdam leads to a WF of 3 245 l/cap/d, an amount that exceeds the direct water use of the city (49.6 m^3/cap/year which equals 138 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2 220 l/cap/d, so a reduction of 32%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 38% reduction to 1 999 litres/cap/day) and a vegetarian diet (a 42% reduction to 1 883 l/cap/d). Amsterdam's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565, 232–239

Ankara

39°55′11″ N | 32°51′15″ E *Country: Turkey, Region: Central Anatolia*

National Flag

Coat of Arms

Ataturk Mausoleum, Anitkabir, monumental tomb of Mustafa Kemal Ataturk, first president of Turkey in Ankara. © canyalcin / Shutterstock.com | Below: Ankara Castle. © muratart / Shutterstock.com

ANKARA

Ankara is the capital of Turkey and the country's second largest city. Its elevation of 938 m reflects its central geographic location, where it is at a strategic crossroads of trade, at the hub of Turkey's highway and rail networks, and serving as the principal market for the surrounding agricultural area. The average number of inhabitants per household is 3.9. Ankara has a stable continental climate, with cold, snowy winters and hot, dry summers, due to its elevation and inland location. Rainfall occurs mostly during the spring and autumn. Ankara's annual average precipitation is fairly low at 408 mm, and the city has experienced increased frequency of severe droughts in recent decades, in 1973, 1977, 1984, 1989-91, 1999-2000 and 2006-08.

Resident population (x 10000)	4 588
Population density (inhabitants/km²)	187
Waste production kg/cap/year	410
% Recycling and composting	1
% Incineration with energy recovery	0
% Landfill	99

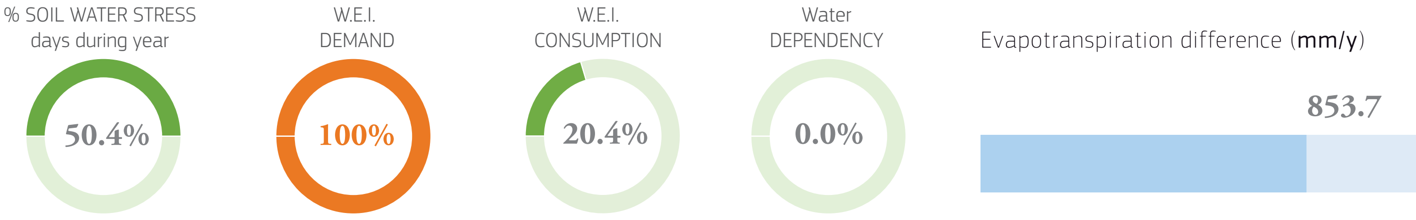
ENVIRONMENTAL QUALITY

Ankara is also at an ecological crossroads, demonstrating features of Irano-Turanian and Euro-Siberian ecological zones. However, due to many years of growing urbanisation, the region has lost much of its natural habitat characteristics.

As in most cities, air pollution is a major concern. Ankara has made efforts to reduce emissions from cars, and pays particular attention to promoting green spaces and forest areas in the city. Waste management is an issue. Waste collection is very efficient, but most is still landfilled. First steps have been taken to introduce recycling and composting, but uncontrolled waste disposal is still a significant contributor to environmental degradation.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



ANKARA

CITY BLUEPRINT ©

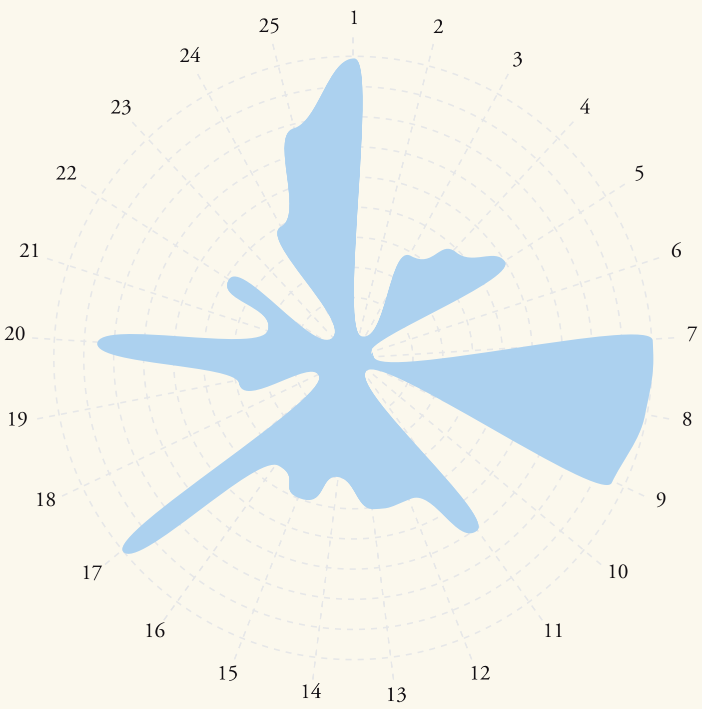
Ankara excels in water conservation and fully separates their stormwater and wastewater to prevent flooding. There is stillv room to improve the city's solid waste treatment and climate change adaptation policy.

The BCI (Blue City Index) is 3.7

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **3.7**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	10.0
2	Tertiary WWT	0.6
3	Groundwater Quality	4.0
4	Solid Waste Collected	5.1
5	Solid Waste Recycled	0.1
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	9.5
10	Nutrient Recovery	0.0
11	Energy Recovery	7.0
12	Sewage Sludge Recycling	5.0
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	4.0
15	Operation Cost Recovery	4.5
16	Water System Leakages	4.2
17	Stormwater Separation	10.0
18	Green Space	1.3
19	Climate Adaptation	4.0
20	Drinking Water Consumption	8.7
21	Climate Robust Buildings	3.0
22	Management and Action Plans	5.0
23	Public Participation	0.5
24	Water Efficiency Measures	5.0
25	Attractiveness	8.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Ankara, Capital city of Turkey © muratart / Shutterstock.com

WATER BASICS

Water stress factors are population growth and increasing standards of living, combined with limited access to new freshwater resources. The main supplies are from reservoirs around the capital, managed by Ankara Water and Sewerage Administration (ASKİ). In 2007, some reservoirs nearly dried up, promoting significant upgrading investments and programmes to improve water efficiency by users.

Annual average rainfall (mm)	402
Daily average air temperature (°C)	10.0
% of blue and green area	20.0
% of soil sealed	40.0
% flooded by 1-m sea-level rise	0
% flooded by 1-m river-level rise	0-5

DRINKING WATER

Drinking water quality in Ankara is monitored regularly, and results prove generally good. There have been some concerns regarding presumed incidences of pollution of the water supply system in recent years. This is being addressed, in part by the new Drinking Water Phase II Gerede System, to construct a new 1.2 billion m^3 capacity reservoir and 32-km transmission tunnel (due for completion in 2015).

% of drinking water samples complying with drinking water regulation	95
% urban population with access to potable drinking water	100
% leakage rate water distribution system	29.0
Drinking water consumption (m^3/cap/year)	72.9
Drinking water consumption (litres/cap/day)	205

WASTEWATER

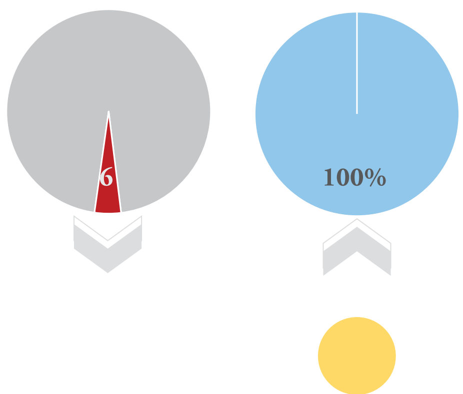
Access to adequate sanitation has increased substantially during the past 10 years due to investments. The Ankara Central Wastewater Treatment Plant (765 000 m^3 per day capacity) treats domestic and industrial effluent with a mechanical-biological activated sludge process. The facility co-generates its energy from a biogas reactor achieving an average of 70% of its total installed power requirements (10 MW).

% population connected to at least secondary wastewater treatment	100
% population connected to tertiary wastewater treatment	6.2
% wastewater that is treated with nutrient-recovering techniques	0
% wastewater treated with energy-recovering techniques	70
Average age of sewer (years)	40
% sewer with separated stormwater and sanitary water	100

Kocatepe Mosque at dusk.
© M DOGAN / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



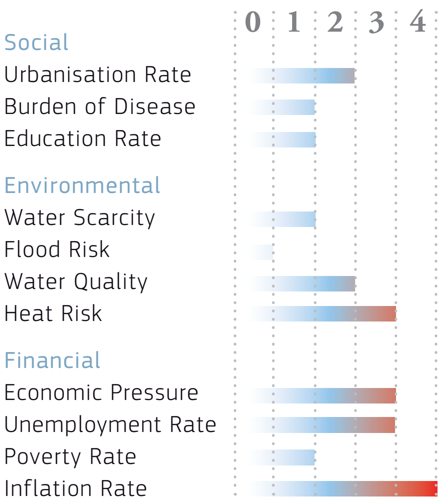
ALERT: 0 WARNING: 0 WATCH: 6

Stress incidents for drought level

Old town (Kaleici) in Ankara, Turkey © muratart / Shutterstock.com

TRENDS & PRESSURES

2.0

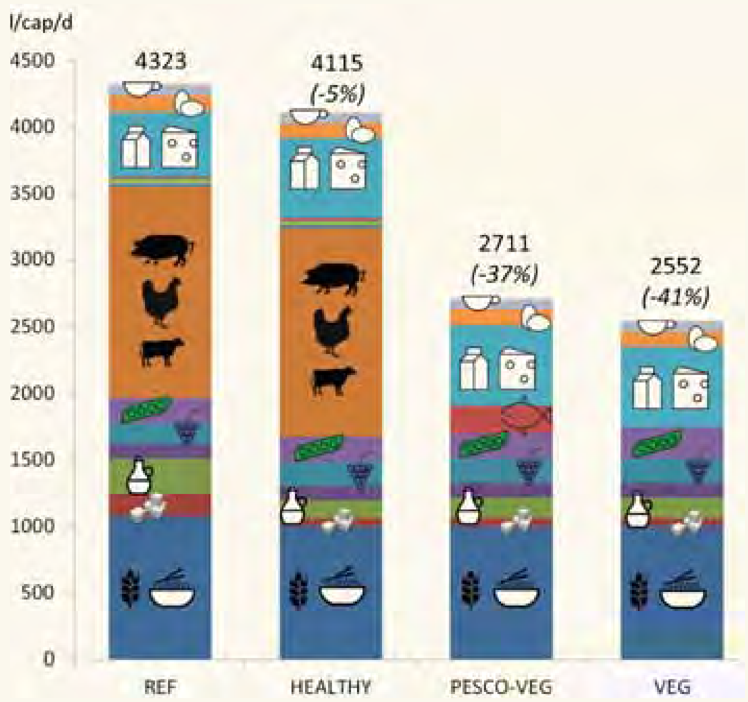


Within this table, lower numbers are better.

ANKARA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Ankara. Four diet scenarios are shown. The current diet of the inhabitants of Ankara leads to a WF of 4 323 l/cap/d, an amount that exceeds the direct water use of the city (73.9 m^3/cap/year which equals 205 l/cap/d) substantially. A healthy diet as recommended by dietary guidelines for Turkey leads to a WF of 4 115 l/cap/d, so a reduction of 5%. Even greater reductions in the WF are observed for a pesco- vegetarian diet (a 37% reduction to 2 711 l/cap/d) and a vegetarian diet (a 41% reduction to 2 552 l/cap/d). Ankara's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:

Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M.,2016. Water consumption related to different diets in Mediterranean cities. Science of The Total Environment, 573, 96–105

Athens

37°58′46″ N | 23°42′58″ E *Country: Greece, Region: Athens*

National Flag

City Flag

Coat of Arms

Cityscape with the Acropolis of Athens (seen from Philopappos Hill). © WitR / Shutterstock.com | Below: The Odeon theatre in Athens. © Tatiana Popova / Shutterstock.com

ATHENS

Athens, the capital of Greece, and the southernmost capital on the European mainland, is a major population centre of approximately 7000 000 in the city itself and reaching 4 million in the wider urban zone.

Athens is situated in the central plain of Attica, surrounded by four large mountains: Mounts Aegalea, Parnitha, Penteli and Hymettus. The city is built around a number of hills, and the geomorphology of Athens is deemed to be one of the most complex in the world. One result is a temperature inversion induced by the mountains, which traps air pollution. Since the late 1970s Athens has embraced the challenge of environmental stewardship and a series of measures taken have resulted in the improvement of the environmental quality of the city.

Resident population (x 1 000)	664
Population density (inhabitants/km²)	17 027
Waste production kg/cap/year	388
% Recycling and composting	19
% Incineration with energy recovery	0
% Landfill	83

ENVIRONMENTAL QUALITY

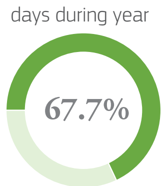
Respect for the environment is a key priority for Athens, but also a major challenge. In addition to the ongoing problem of air pollution, Athens is in a water-scarce region. Water-saving measures and a target of increasing the extent of green open spaces are important elements for achieving improved environmental quality.

An extensive leakage detection and repair programme has already been undertaken, resulting in reduction of leakages by almost 20% over the past 10 years. However, demand has now reached the capacity of the system. Athens is implementing an improved waste management system to make the most effective use of human resources and facilitate citizens in terms of managing waste.

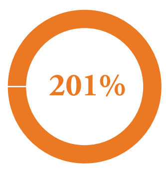
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

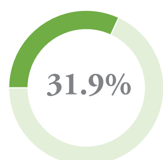
% SOIL WATER STRESS days during year



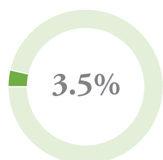
W.E.I. DEMAND



W.E.I. CONSUMPTION



Water DEPENDENCY



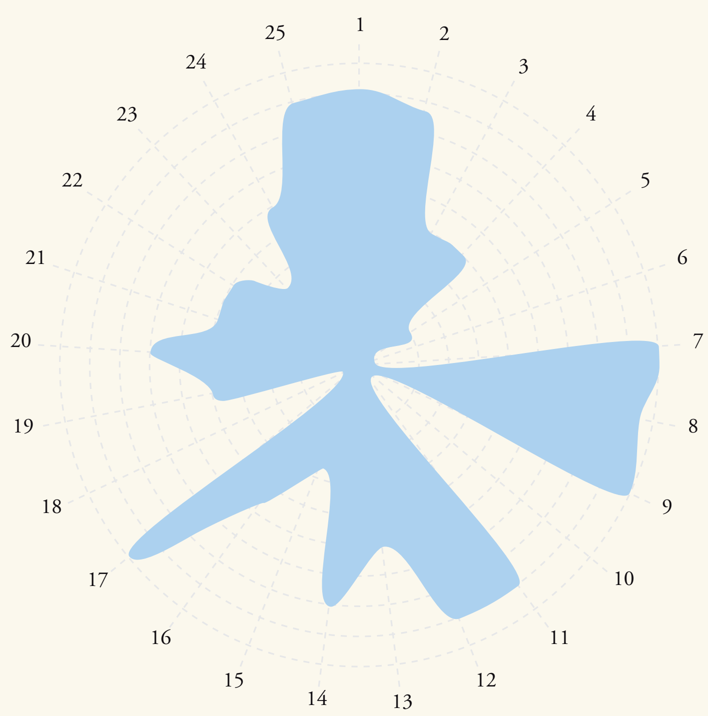
Evapotranspiration difference (**mm/y**)

ATHENS

CITY BLUEPRINT ©

Athen's water infrastructure is in good condition, and wastewater treatment is adequate. Yet, the city's solid waste treatment and climate change adaptation policy can improve considerably.

The BCI (Blue City Index) **is** 4.9



The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **4.9**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	9.2
2	Tertiary WWT	8.6
3	Groundwater Quality	5.0
4	Solid Waste Collected	5.4
5	Solid Waste Recycled	1.9
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.5
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	9.2
12	Sewage Sludge Recycling	9.2
13	WWT Energy Efficiency	6.0
14	Average Age Sewer	8.0
15	Operation Cost Recovery	3.6
16	Water System Leakages	5.6
17	Stormwater Separation	9.7
18	Green Space	0.0
19	Climate Adaptation	5.0
20	Drinking Water Consumption	7.3
21	Climate Robust Buildings	5.0
22	Management and Action Plans	5.0
23	Public Participation	3.5
24	Water Efficiency Measures	6.0
25	Attractiveness	9.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., 2013. City Blueprints: Baseline Assessments of Sustainable Water Management in 11 Cities of the Future. Water Resources Management, 27, 5191-5206
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Morning in Mikrolimano marina in Athens, Greece. © Milan Gonda / Shutterstock.com | Below: The Changing of the Guard ceremony takes place in front of the Greek Parliament Building. © Markus Gebauer: / Shutterstock.com

WATER BASICS

The city is supplied by a comprehensive canal system from a number of reservoirs, the furthest 200 km distant. This presents challenges for operation, long-term planning and security. The water supply system is a major user of electricity. To improve energy efficiency, the water company uses a computer monitoring and control model from the National Technical University of Athens, and has installed small hydroelectric plants.

Annual average rainfall (mm)	365
Daily average air temperature (°C)	18.5
% of blue and green area	14.1
% of soil sealed	72.2
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	44.8

DRINKING WATER

Drinking water originates from a combination of upland surface water sources (97.7%) and groundwater sources (2.2%). There is 100% population coverage. The total water consumption in Athens is 105.8 m^3 per person per year. The quality of the supplied water is very good.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	22.0
Drinking water consumption (m^3/cap/year)	104.8
Drinking water consumption (litres/cap/day)	291

WASTEWATER

Ninety per cent of the population is covered by adequate wastewater collection and treatment. It has mostly separated sanitary and stormwater sewers, representing an impressive 97% of the total infrastructure. Measures have been taken to recover energy from wastewater (100% of the wastewater) but there is no nutrient recovery.

% population connected to at least secondary wastewater treatment	92.4
% population connected to tertiary wastewater treatment	86.2
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater treated with energy-recovering techniques	100
Average age of sewer (years)	20
% sewer with separated stormwater and sanitary water	97.2

Detail of Erechtheion in Acropolis.
© Kite_rin / Shutterstock.com

GREECE

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 64%

2036-2065 77%

2066-2095 100%

0 400%

Average % change in population directly affected

2006-2035 86%

2036-2065 91%

2066-2095 131%

0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

ATTIKA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 0 M€

0 300M€

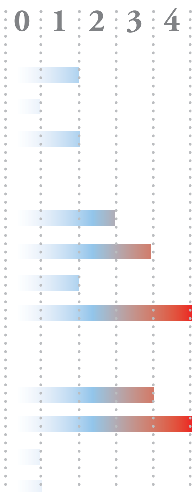
Population directly affected: 0 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

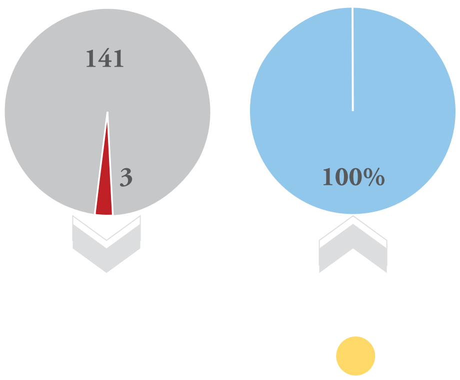
1.7



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



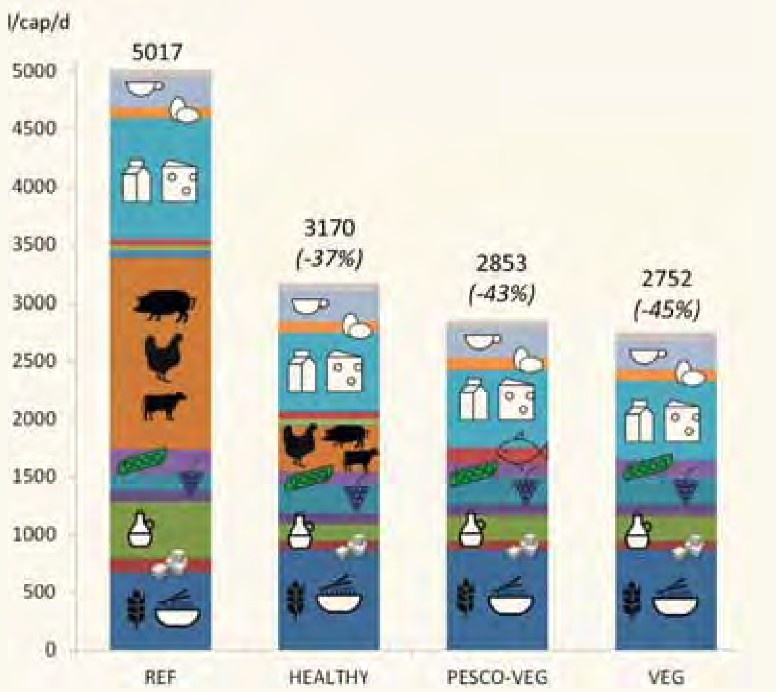
ALERT: 0 WARNING: 0 WATCH: 3

Stress incidents for drought level

ATHENS

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Athens. Four diet scenarios are shown. The current diet of the inhabitants of Athens leads to a WF of 5 017 l/cap/d, an amount that exceeds the direct water use of the city (104.8 m^3/cap/year which equals 291 l/cap/d) substantially. A healthy Mediterranean diet leads to a WF of 3 170 l/cap/d, so a reduction of 37%. Even larger reductions in the WF are observed for a pesco-vegetarian diet (a 43% reduction to 2 853 l/cap/d) and a vegetarian diet (a 45% reduction to 2 752 l/cap/d). Athens' citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

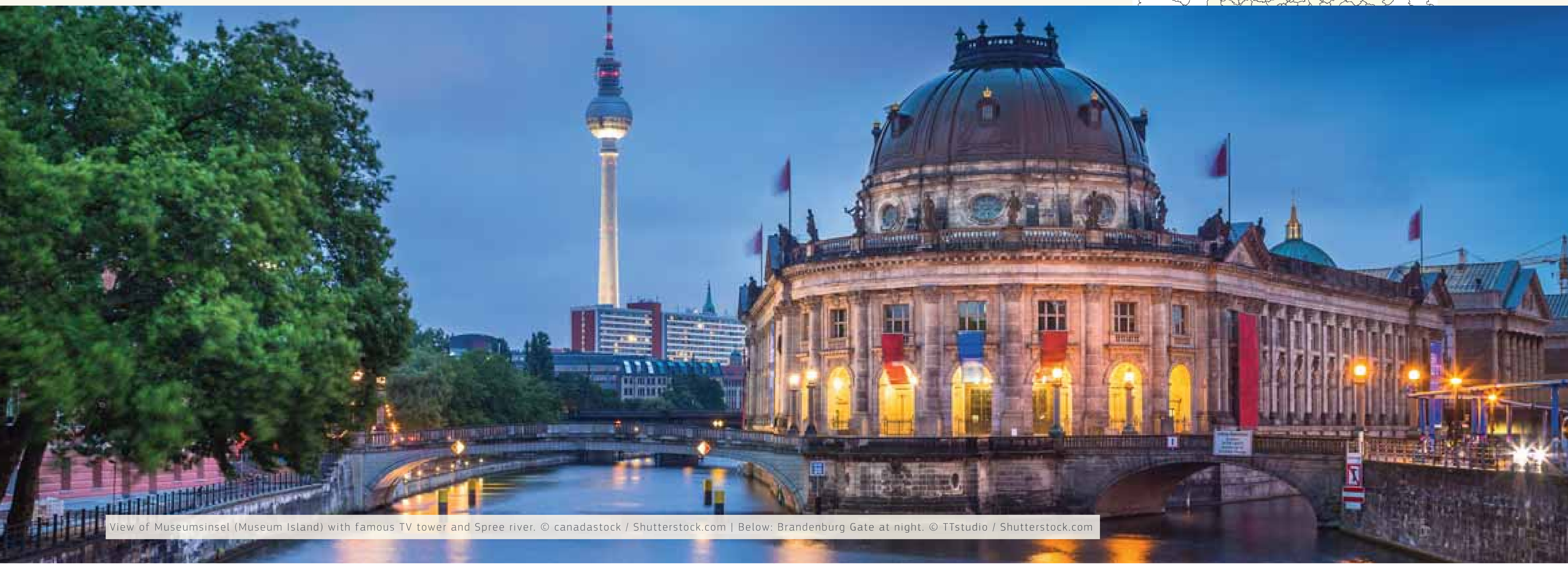
References:

Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M.,2016. Water consumption related to different diets in Mediterranean cities. Science of The Total Environment, 573, 96–105

Berlin

52°31'27" N | 13°24'37" E   *Country: Germany, Region: Berlin*

National Flag   City Flag   Coat of Arms



View of Museumsinsel (Museum Island) with famous TV tower and Spree river. © canadastock / Shutterstock.com | Below: Brandenburg Gate at night. © TTstudio / Shutterstock.com

BERLIN

Berlin is the capital and centre of economic and political decision-making in Germany. It is located on the east-west axis linking Paris, Warsaw and Moscow, and the north-south axis linking Stockholm, Prague, Vienna and Budapest. With a total area of approximately 900 km², Berlin is one of the most important urban centres in Europe. About 40% of its 3.5 million residents are younger than 35 and, with a population growth of more than 40 000 a year, the city's appeal is unbroken.

Berlin has a continental climate, with cold winters and often quite hot summers. from December to February, freezing temperatures can continue for many weeks, while from June to August, the mean temperature is around 17°C, but occasionally exceeding 30°C

Resident population (x 1 000)	3 422
Population density (inhabitants/km²)	3 837
Waste production kg/cap/year	600
% Recycling and composting	63
% Incineration with energy recovery	16
% Landfill	0

ENVIRONMENTAL QUALITY

Berlin is a relatively green and blue city, with a quarter of its area covered by forests and parks, and a tenth by lakes, rivers and canals. The city has an active policy of environmental protection, and promotes sustainable urban living, for example, by introducing low-vehicle-emission zones. An important goal is the reduction of environmental impacts in the city centre. Improving natural ecosystems and biodiversity, while maintaining the current land use, are central to this endeavour. Drinking water is abstracted solely from groundwater, but this relies partially on surface water infiltration. Consequently, surface-and groundwater bodies are carefully monitored and protected.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year	W.E.I. DEMAND	W.E.I. CONSUMPTION	Water DEPENDENCY
39.6%	54.4%	4.0%	29.2%

Evapotranspiration difference (**mm/y**)

576.3

BERLIN

CITY BLUEPRINT ©

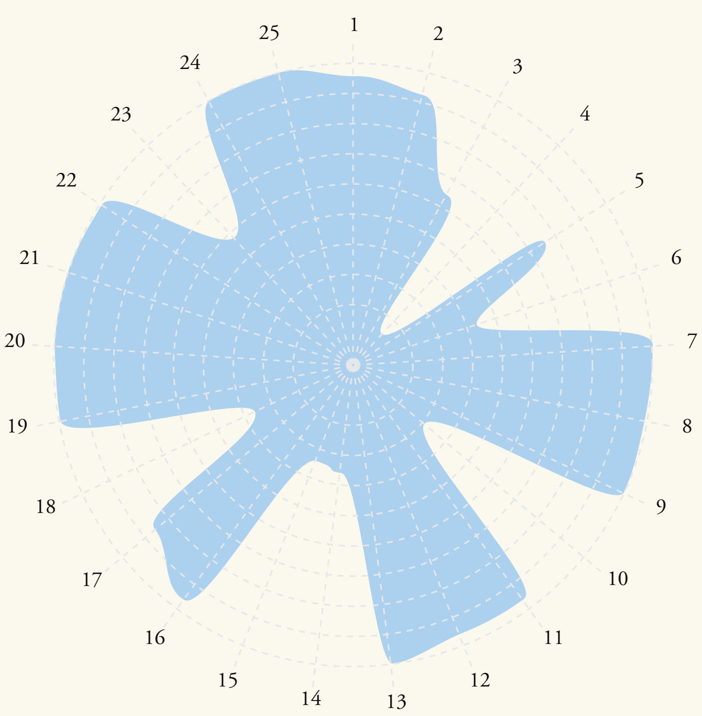
Berlin is an attractive city that performs well on water management, especially climate adaptation policy. However, solid waste collection, nutrient recovery from waste water and the urban coverage of green spaces, need improvement.

The BCI (Blue City Index) **is 7.2**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **7.2**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.6
2	Tertiary WWT	9.3
3	Groundwater Quality	6.4
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	7.5
6	Solid Waste Energy Recovered	4.3
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	2.9
11	Energy Recovery	9.6
12	Sewage Sludge Recycling	9.6
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	3.5
15	Operation Cost Recovery	3.3
16	Water System Leakages	9.6
17	Stormwater Separation	8.2
18	Green Space	3.8
19	Climate Adaptation	10.0
20	Drinking Water Consumption	9.6
21	Climate Robust Buildings	10.0
22	Management and Action Plans	10.0
23	Public Participation	5.8
24	Water Efficiency Measures	10.0
25	Attractiveness	10.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Aerial view of Berlin skyline panorama with Grosser Tiergarten public park on a sunny day with blue sky and clouds in summer seen from Berlin Victory Column (Berliner Siegessaeule). © canadastock / Shutterstock.com

WATER BASICS

The pressures on, and vulnerability of Berlin's water resources mean sustainable water management is critical. Water is extracted only from within the city confines and water efficiency programmes are implemented. Water withdrawal must be proportional to replenishment, and essential water bodies are controlled and monitored while applying high standards of wastewater treatment and promoting storm water retention.

Annual average rainfall (mm)	566
Daily average air temperature (°C)	9.0
% of blue and green area	28
% of soil sealed	49.5
% flooded by 1-m sea-level rise	0
% flooded by 1-m river-level rise	23.8

DRINKING WATER

Drinking water quality is high, helped by pristine raw groundwater. Treatment is limited to iron and manganese removal, with no chlorination (since 1992), except for emergencies. The mineral-rich water is 'medium hard to hard', but does not require softening for most uses. A source of concern is lead contamination from old pipes, but with the population boom and modernisation of infrastructure, this becomes less of an issue.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	2.0
Drinking water consumption (m^3/cap/year)	54
Drinking water consumption (litres/cap/day)	150

WASTEWATER

Berlin has continuously enhanced the performance of its wastewater treatment plants, taking a global lead in the use of suitable technologies. 81% less phosphorus and 98% less ammoniacal nitrogen are discharged today into the Spree and Havel rivers from Berlin plants, thanks to more than €4 billion of investment in the capital's infrastructure since 1990.

% population connected to at least secondary wastewater treatment	96.3
% population connected to tertiary wastewater treatment	93.4
% wastewater that is treated with nutrient-recovering techniques	29.7
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	43
% sewer with separated stormwater and sanitary water	81.7

East Side Gallery with an old Trabant
© canadastock / Shutterstock.com

GERMANY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 158%

2036-2065 146%

2066-2095 177%

0 400%

Average % change in population directly affected

2006-2035 184%

2036-2065 146%

2066-2095 211%

0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

BERLIN

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 5,7M€

0 300M€

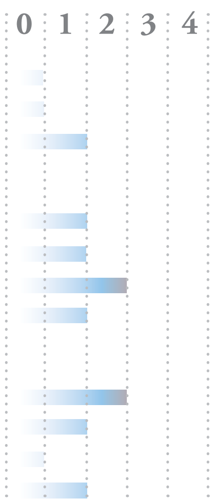
Population directly affected: 1886 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

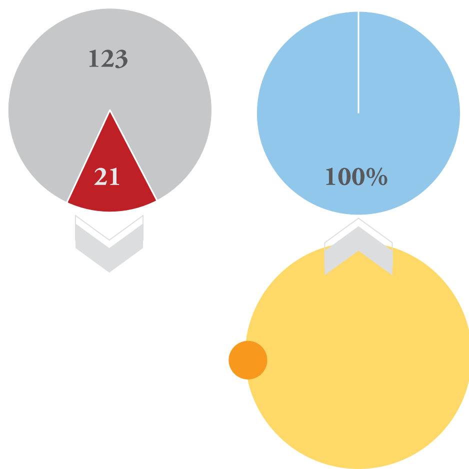
1.1



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



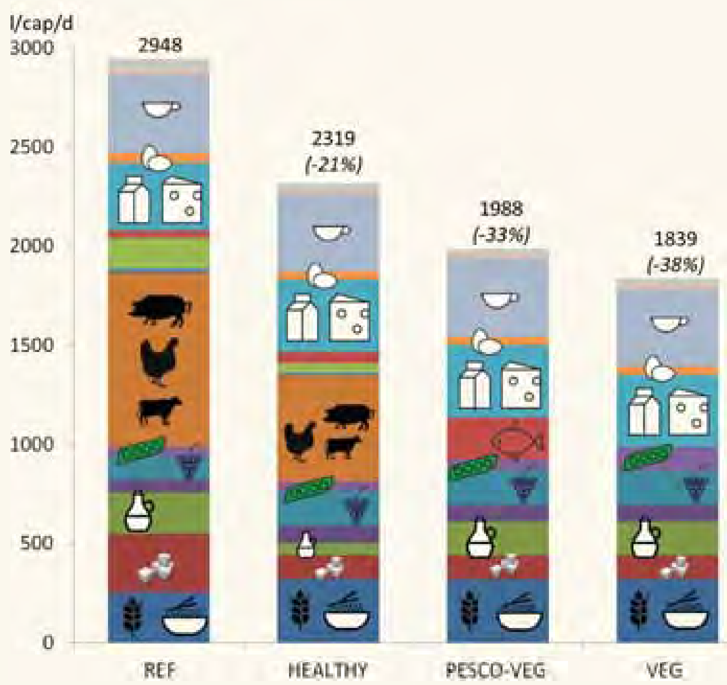
ALERT: 0 WARNING: 3 WATCH: 18

Stress incidents for drought level

BERLIN

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Berlin. Four diet scenarios are shown. The current diet of the inhabitants of Berlin leads to a WF of 2 948 l/cap/d, an amount that exceeds the direct water use of the city (54 m^3/cap/year which equals 150 l/cap/d) substantially. A healthy diet, as recommended by national German dietary guidelines (lebensmittelbezogene Empfehlungen, Deutsche Gesellschaft für Ernährung), leads to a WF of 2 319 l/cap/d, so a reduction of 21%. Even greater reductions in the WF are observed for a pesco vegetarian diet (a 33% reduction to 1 988 l/cap/d) and a vegetarian diet (a 38% reduction to 1 839 l/cap/d). Berlin's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

Bologna

44°29′37″ N | 11°20′19″ E   *Country: Italy, Region: Emilia-Romagna*

National Flag   City Flag   Coat of Arms

Aerial panoramic cityscape of Bologna, Italy. © GoneWithTheWind / Shutterstock.com | Below: Steady works painted on the wall of the houses in the medieval small village of Dozza near Bologna. © GoneWithTheWind / Shutterstock.com

BOLOGNA

Bologna is a medieval town, with a population of nearly 400 000, in the Emilia Romagna region of Northern Italy, founded by the Etruscans, with a history of trade and learning. The University of Bologna, founded in 1088, is the oldest in the world. Bologna is considered one of the top cities in Italy for quality of life. The local economy is based on small- and medium-sized enterprises, with a reputation for prestige of national importance, contributing greatly to the richness of the territory.

The city is on the edge of the Po Plain, at the foot of the Apennine Mountains. It is at the conjunction of two river valleys, the Reno and Savena, although they are not linked to the Po basin.

Bologna has a humid subtropical climate with little influence from the sea, resulting in rather cold winters for the Apennine Peninsula.

ENVIRONMENTAL QUALITY

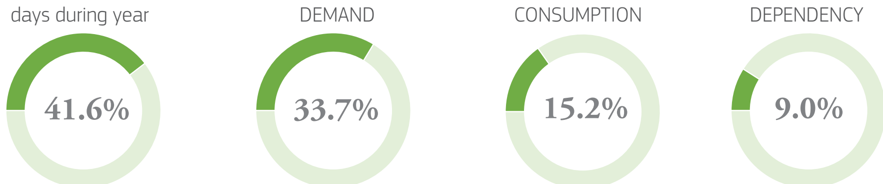
The Municipality of Bologna has been involved for years in several European projects focused on protecting the environment and sustainable urban redevelopment. Of special focus are actions to increase energy efficiency and the use of renewable energy in the urban and industrial area, focusing on the construction industry, service sector, local energy production, mobility and public facilities. Bologna pays a great deal of attention to stakeholder engagement and participation, which leads to increased commitments and a consequent reduction in emissions.

The city also promotes green roofs, eco-innovation and circular economy aspects.

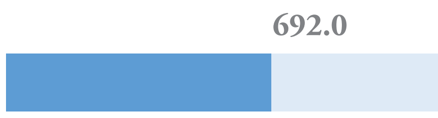
Resident population (x 1,000)	384
Population density (inhabitants/km²)	2 728
Waste production kg/cap/year	540
% Recycling and composting	34
% Incineration with energy recovery	17
% Landfill	49

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



Evapotranspiration difference (**mm/y**)



BOLOGNA

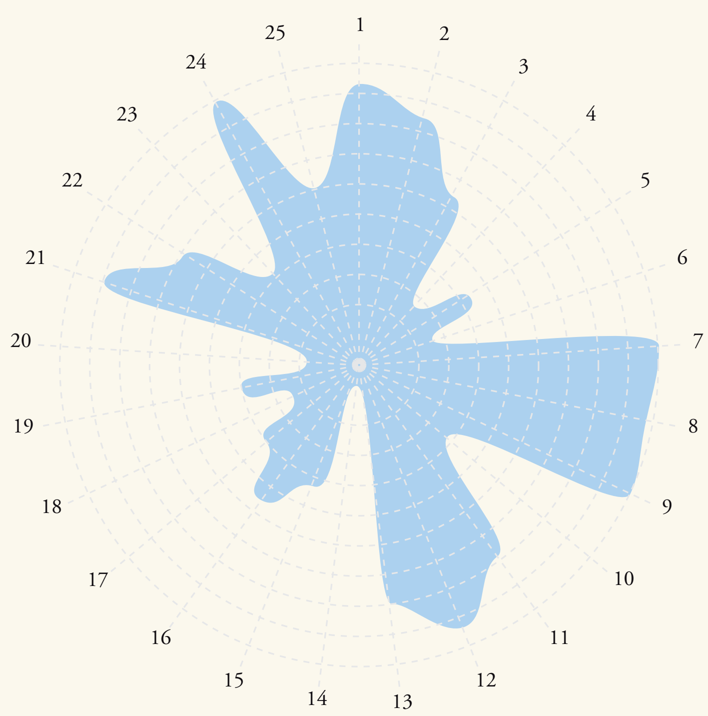
CITY BLUEPRINT ©

Bologna's wastewater treatment is of good quality and includes energy recovery. However, Bologna faces considerable challenges regarding sewer maintenance, climate adaptation, water conservation and solid waste treatment.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **5.2**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.4
2	Tertiary WWT	8.4
3	Groundwater Quality	6.5
4	Solid Waste Collected	2.7
5	Solid Waste Recycled	4.1
6	Solid Waste Energy Recovered	2.6
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.8
9	Drinking Water Quality	9.9
10	Nutrient Recovery	3.8
11	Energy Recovery	7.9
12	Sewage Sludge Recycling	9.2
13	WWT Energy Efficiency	8.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	4.3
16	Water System Leakages	5.7
17	Stormwater Separation	4.0
18	Green Space	2.6
19	Climate Adaptation	4.0
20	Drinking Water Consumption	1.9
21	Climate Robust Buildings	9.0
22	Management and Action Plans	7.0
23	Public Participation	4.2
24	Water Efficiency Measures	10.0
25	Attractiveness	6.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

The Teatro Comunale di Bologna © muratart / Shutterstock.com

WATER BASICS

Bologna receives its water from a mix of different sources: 53% from groundwater (including natural springs) and 47% from surface water, mostly the Setta river. The local water supplier and regional government work closely to ensure proper protection of the water abstraction sites. In the Bologna area there are more than 250 abstraction points. 22% of the water (groundwater only) can be used directly with simple disinfection, whereas the largest share (78%, including all surface water) requires additional treatment.

Annual average rainfall (mm)	708
Daily average air temperature (°C)	13.2
% of blue and green area	24.2
% of soil sealed	52.5
% flooded by 1-m sea-level rise	0
% flooded by 1-m river-level rise	52.6

DRINKING WATER

The drinking water distribution system has a total length of about 7 000 km and some 67 000 analyses are performed each year to ensure compliance with drinking water standards. HERA, the water supply utility, has implemented a modern ICT system to rapidly communicate with households in the case of supply problems. Results prove high to excellent drinking water quality in Bologna.

% of drinking water samples complying with drinking water regulation	99
% urban population with access to potable drinking water	100
% leakage rate water distribution system	21.3
Drinking water consumption (m^3/cap/year)	224
Drinking water consumption (litres/cap/day)	622

WASTEWATER

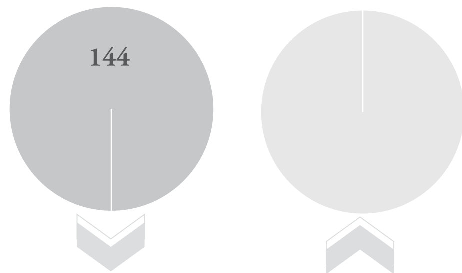
94% of the population are connected to secondary wastewater treatment systems, and 84% to tertiary treatment. Constructed wetland systems are included in the system. This scale of treatment helps improve the ecology of the region, creating natural environments and landscapes of aesthetic appeal to inhabitants, and attractive to wildlife, including various species of birds, amphibians and reptiles.

% population connected to at least secondary wastewater treatment	94.0
% population connected to tertiary wastewater treatment	84.0
% wastewater that is treated with nutrient-recovering techniques	40.0
% wastewater that is treated with energy-recovering techniques	84.0
Average age of sewer (years)	60
% sewer with separated stormwater and sanitary water	40

Piazza del Nettuno fountain in Bologna.
© s74 / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 0 WARNING: 0 WATCH: 0

Stress incidents for drought level

ITALY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 48%

2036-2065 177%

2066-2095 394%

0 400%

Average % change in population directly affected

2006-2035 105%

2036-2065 283%

2066-2095 515%

0 550%

EMILIA ROMAGNA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 213M€

0 300M€

Population directly affected: 2000 inh.

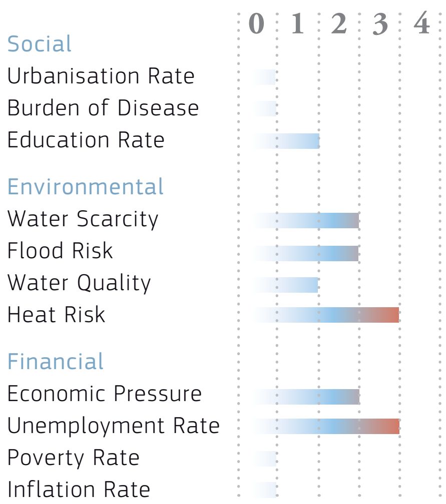
0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

TRENDS & PRESSURES

1.4

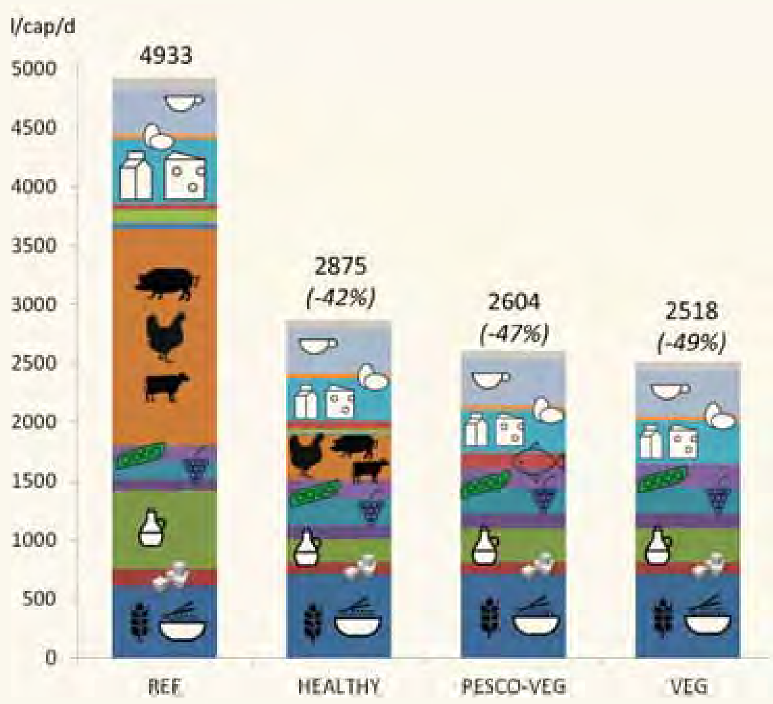


Within this table, lower numbers are better.

BOLOGNA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



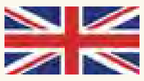
This figure shows the water footprint (WF) related to food consumption for Bologna. Four diet scenarios are shown. The current diet of the inhabitants of Bologna leads to a WF of 4 933 l/cap/d, an amount that exceeds the direct water use of the city (224 m^3/cap/year which equals 622 l/cap/d) substantially. A healthy diet, as recommended by the Italian National Research Institute on Food and Nutrition (INRAN, Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione; Linee guida per una sana alimentazione italiana) leads to a WF of 2 875 l/cap/d, so a reduction of 42%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 47% reduction to 2 604 l/cap/d) and a vegetarian diet (a 49% reduction to 2 518 l/cap/d). Bologna citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M.,2016. Water consumption related to different diets in Mediterranean cities. Science of The Total Environment, 573, 96–105

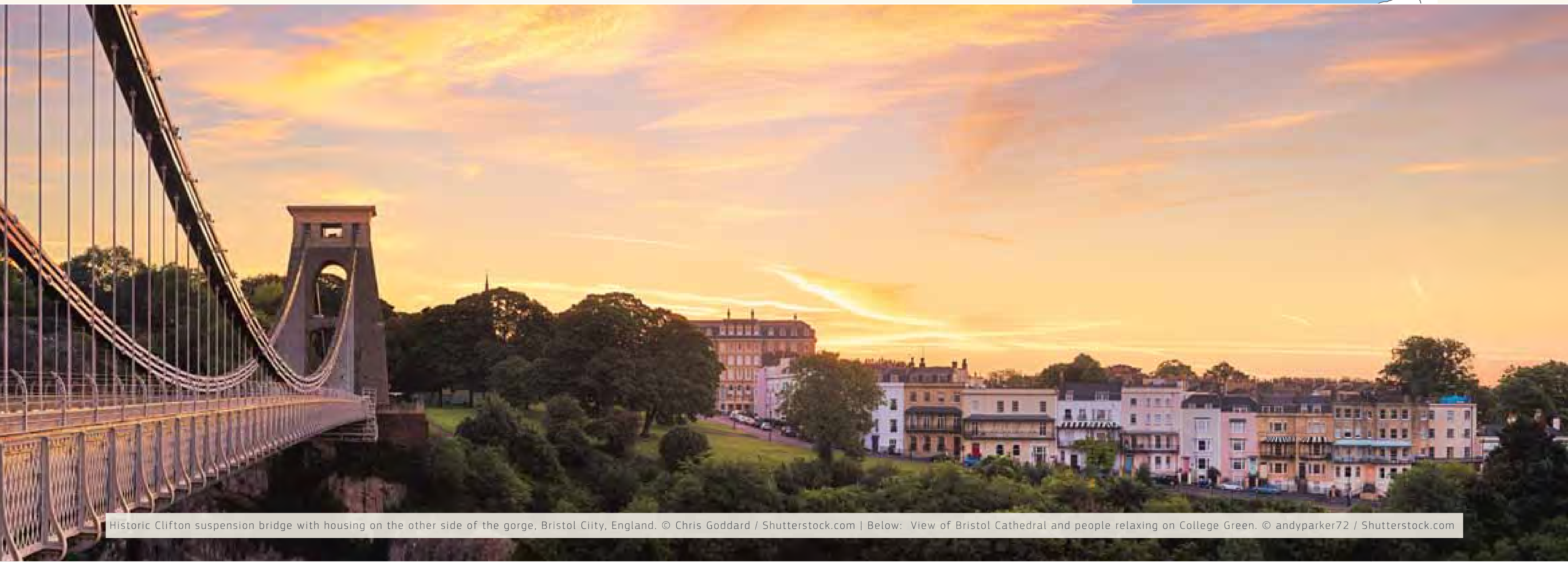
Bristol

51°27′18″ N | 2°35′47″ W *Country: England, Region: South West England*



National Flag

Coat of Arms



Historic Clifton suspension bridge with housing on the other side of the gorge, Bristol Ciity, England. © Chris Goddard / Shutterstock.com | Below: View of Bristol Cathedral and people relaxing on College Green. © andyparker72 / Shutterstock.com

BRISTOL

Bristol, in south west England, has a population of approximately 440 000, and around 620 000 in the wider urban area. Its prosperity has always been linked to water and the sea. Founded on the River Avon, it has been an important seaport for centuries, with an inland connection to London via rivers and canals. John Cabot (Giovanni Caboti of Venice) sailed from Bristol in 1497 to discover the North American mainland, and the city launched the first ocean-going steam–powered ship in 1838. The historic Harbourside is the cultural heart of the city with leisure, residential and retail developments, and act as a hub for festivals and events. Thus, water remains central to the city's character. Bristol's climate is oceanic, with average temperatures ranging from 5°C to 17°C and rainfall of 626 mm/year.

Resident population (x 1 000)	428
Population density (inhabitants/km²)	1 819
Waste production kg/cap/year	378
% Recycling and composting	50
% Incineration with energy recovery	24
% Landfill	26

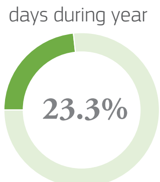
ENVIRONMENTAL QUALITY

Bristol was European Green Capital 2015. Green and blue areas cover almost a third of the city's jurisdiction, including 1 600 ha of green spaces, 350 ha of water, and 6 km of coastline with international wildlife designations (SAC, SPA, Ramsar). Sustainable urban drainage is promoted, including the reduction of impermeable surfaces, to reduce flooding and enhance groundwater recharge. The city's growing population puts pressure on natural systems, yet protected wildlife spaces have increased by 12 ha in recent years, with support from the Bristol Biodiversity Action Plan. Urban quality of life is enhanced by a progressive transport policy, including the UK's most comprehensive cycling infrastructure.

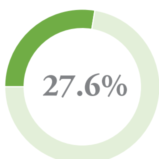
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

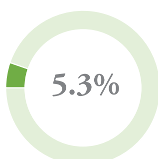
% SOIL WATER STRESS days during year



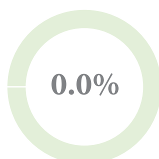
W.E.I. DEMAND



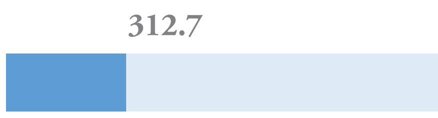
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



BRISTOL

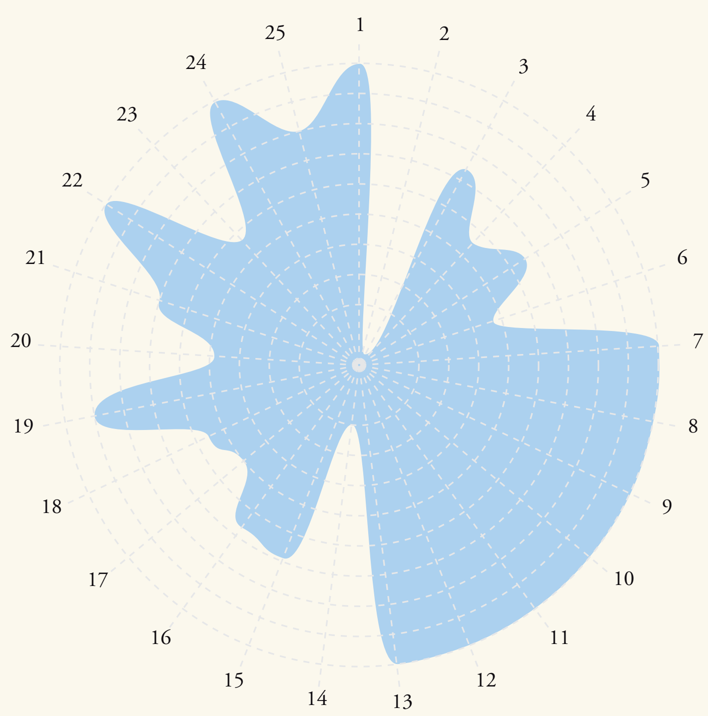
CITY BLUEPRINT ©

Bristol excels in the recovery of energy and nutrients from wastewater. However, tertiary wastewater treatment is lacking and, water conservation and solid waste treatment can be improved.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **6.7**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	10.0
2	Tertiary WWT	0.0
3	Groundwater Quality	7.4
4	Solid Waste Collected	5.6
5	Solid Waste Recycled	6.6
6	Solid Waste Energy Recovered	4.8
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	10.0
11	Energy Recovery	10.0
12	Sewage Sludge Recycling	10.0
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	2.0
15	Operation Cost Recovery	6.9
16	Water System Leakages	6.7
17	Stormwater Separation	5.0
18	Green Space	5.6
19	Climate Adaptation	9.0
20	Drinking Water Consumption	4.9
21	Climate Robust Buildings	7.0
22	Management and Action Plans	10.0
23	Public Participation	5.8
24	Water Efficiency Measures	10.0
25	Attractiveness	8.0

Resident Population data: EUROSTAT, 2014. Population Density data: WIKIPEDIA, 2012

References:
Koop SHA, Easton P, Van Leeuwen CJ (2016) KWR report: City Blueprint Report on Bristol

Clifton Suspension Bridge, Bristol, UK © stocker1970 / Shutterstock.com

WATER BASICS

Drinking water originates from the Mendip Lakes (owned and managed by Bristol Water) and the Gloucester-Sharpness canal, which connects to the River Severn. The lakes and river are protected Natura 2000 sites. Catchment protection zones are enforced for all water sources, with regular quality sampling. Cooperating partners include farmers, landholders, wildlife organisations, environmental regulators and volunteer groups.

Annual average rainfall (mm)	848
Daily average air temperature (°C)	11.5
% of blue and green area	34.0
% of soil sealed	848
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	7.6

UNITED KINGDOM

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 46%

2036-2065 81%

2066-2095 268%

0 400%

Average % change in population directly affected

2006-2035 48%

2036-2065 75%

2066-2095 331%

0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DRINKING WATER

Bristol Water (private) supplies 100% of the population with safe drinking water. Despite a growing population, consumption is the lowest for 20 years, averaging 140 l/cap/day. The system leakage rate is 11.2%. 'Smart' metering services are provided to business users, including data-logging and leakage alarms, to reduce wastage, and facilitate accurate and efficient water-use monitoring.

% of drinking water samples complying with drinking water regulation	848
% urban population with access to potable drinking water	100
% leakage rate water distribution system	16.3
Drinking water consumption (m^3/cap/year)	157
Drinking water consumption (litres/cap/day)	436

GLOUCESTERSHIRE, WILTSHIRE

BRISTOL / BATH

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 10.2M€

0 300M€

Population directly affected: 464 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

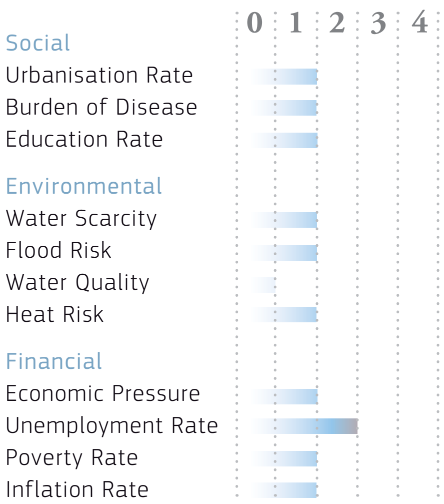
WASTEWATER

100% of the population is connected. The wastewater treatment plant applies 100% secondary treatment and is self-sufficient in electricity, using on-site generated renewable energy. 50% of the 2 000 sewer pipes is a combined system. All sewage sludge is recycled to agricultural land (in accordance with regulations and codes of practice), returning nutrients, carbon and organic matter to the soil in place of chemical fertilisers.

% population connected to at least secondary wastewater treatment	848
% population connected to tertiary wastewater treatment	0.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	50
% sewer with separated stormwater and sanitary water	50

TRENDS & PRESSURES

1.2

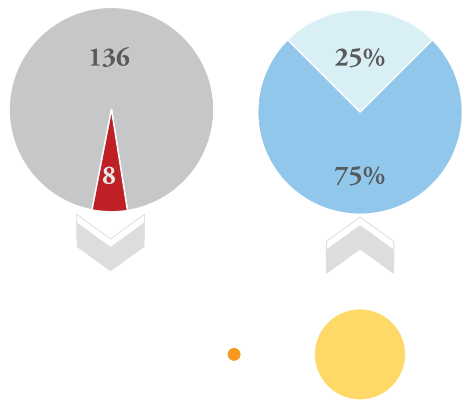


Within this table, lower numbers are better.

Bristol Cathedral, England
© lulu2626 / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



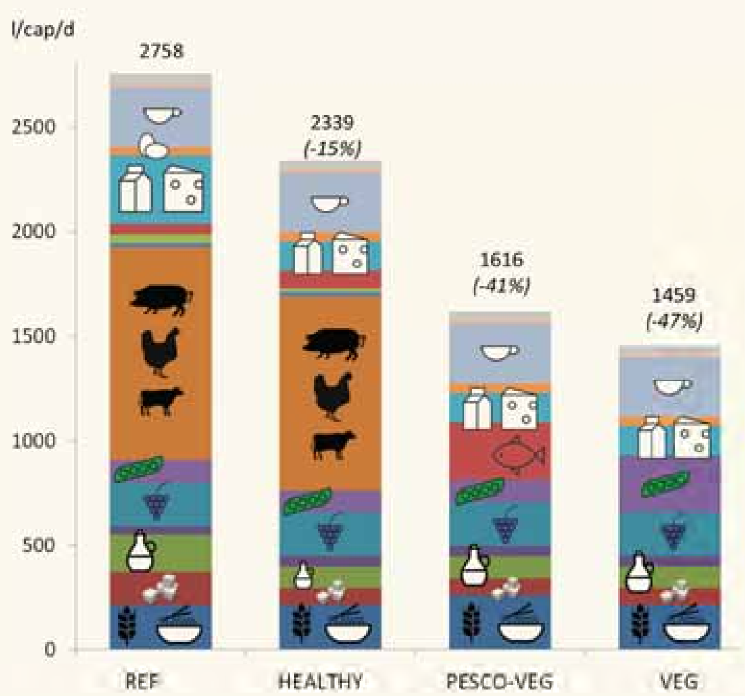
ALERT: 0 WARNING: 1 WATCH: 7

Stress incidents for drought level

BRISTOL

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Bristol. Four diet scenarios are shown. The current diet of the inhabitants of Bristol leads to a WF of 2 758 l/cap/d, an amount that exceeds the direct water use of the city (157 m^3/cap/yr which equals 436 l/cap/d) substantially. A healthy diet as recommended by national UK dietary guidelines (The Eatwell Guide), leads to a WF of 2 339 l/cap/d, so a reduction of 15%. Even greater reductions in the WF are observed for a pesco vegetarian diet (a 41% reduction to 1 616 l/cap/d) and a vegetarian diet (a 47% reduction to 1 459 l/cap/d). Bristol citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

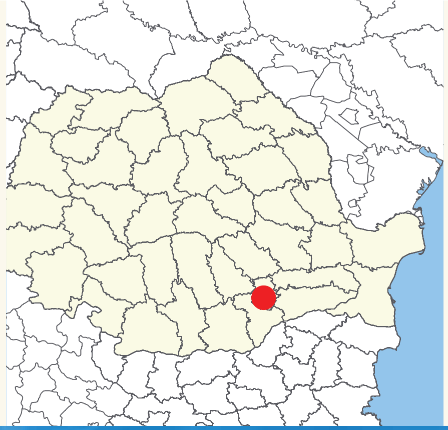
Bucharest

44°25′56″ N | 26°06′22″ E *Country: Romania, Region: București – Ilfov*


National Flag


City Flag


Coat of Arms




House of the Free Press panorama (Casa Presei Libere). © Danilovski / Shutterstock.com | Below: The Romanian Athenaeum George Enescu opened in 1888 is a concert hall in the center of Bucharest. © PhotoStock10 / Shutterstock.com

BUCHAREST

Bucharest is Romania's capital and largest city, as well as its cultural, industrial, and financial centre. Known for its wide, tree-lined boulevards, glorious Belle Époque buildings and a reputation for the high life, Bucharest earned its nickname of "Little Paris" in the early 1900s.
Situated in the south-eastern part of Romania, it lies within the Danube River Basin, but some 70 km north on the banks of the tributary Dâmbovița River. With approximately 2 million inhabitants, Bucharest is the sixth largest city in the EU. It covers an area of 226 km^2 and has a humid continental climate, with sometimes windy winters. Although located on a river, Bucharest has never functioned as a port city.

Resident population (x 1 000)	2 104
Population density (inhabitants/km^2)	8 024
Waste production kg/cap/year	350
% Recycling and composting	1
% Incineration with energy recovery	0
% Landfill	99

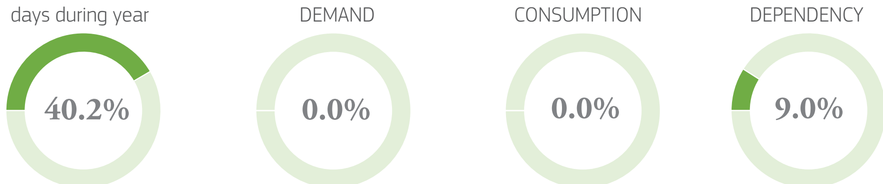
ENVIRONMENTAL QUALITY

For Bucharest, the challenge of improving the ecological conditions is a current and major strategic objective of the General Urban Development Plan. Bucharest is one of Romania's most polluted cities, with intense traffic being the main cause of air pollution. Its urban area is expected to continue growing at a significant rate. Water is another priority in Bucharest. Despite the challenging environmental situation, the municipality and water supplier work together to raise awareness in their inhabitants and customers of responsible water resource management and wastewater treatment, and the impacts of those services on the environment, for example, by monitoring carbon footprints.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year | W.E.I. DEMAND | W.E.I. CONSUMPTION | Water DEPENDENCY



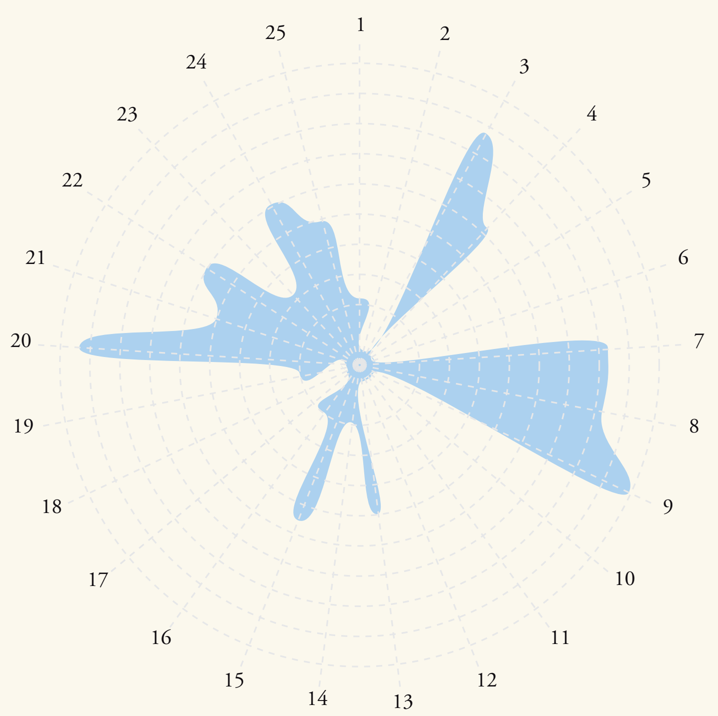
Evapotranspiration difference (**mm/y**)

BUCHAREST

CITY BLUEPRINT ©

Bucharest's water consumption and solid waste production are very low. Nevertheless, strong efforts are needed to improve wastewater treatment, reduce water leakages and incorporate blue-green infrastructure to reduce climate vulnerability.

The BCI (Blue City Index) **is 2.4**



The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).
The Blue City Index is **2.4**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	2.1
2	Tertiary WWT	0.0
3	Groundwater Quality	8.7
4	Solid Waste Collected	6.1
5	Solid Waste Recycled	0.1
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	8.2
8	Access to Sanitation	8.2
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	2.0
15	Operation Cost Recovery	5.5
16	Water System Leakages	2.0
17	Stormwater Separation	0.1
18	Green Space	0.0
19	Climate Adaptation	2.0
20	Drinking Water Consumption	9.4
21	Climate Robust Buildings	5.0
22	Management and Action Plans	6.0
23	Public Participation	3.1
24	Water Efficiency Measures	6.0
25	Attractiveness	5.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., 2013. City Blueprints: Baseline Assessments of Sustainable Water Management in 11 Cities of the Future. Water Resources Management, 27, 5191-5206
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Aerial view of the Tei Lake (Linden Tree Lake) and its neighborhood in the Bucharest Northern Side. © Photosebia / Shutterstock.com

WATER BASICS

Bucharest receives most of its water from external sources. Based on available national and regional information, it can be concluded that the environmental quality of water (surface water, groundwater and biodiversity) in Romania is generally good, but is very likely lower in Bucharest, with its generally high pollution levels and rapid development. Citizens of Bucharest are concerned about this issue.

Annual average rainfall (mm)	580
Daily average air temperature (°C)	11.0
% of blue and green area	15.4
% of soil sealed	77.9
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	1.4

ROMANIA

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	140%
2036-2065	147%
2066-2095	134%
0	400%

Average % change in population directly affected

2006-2035	117%
2036-2065	122%
2066-2095	180%
0	550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DRINKING WATER

Drinking water, supplied by Apa Nova (a Veolia company), originates mostly from surface water (99.9%) and a small amount from groundwater (0.1%), and serves 82% of the population. The leakage rate is high but improving, having reduced from 46% in 2001 to 40% in 2011. A comprehensive water monitoring programme shows that delivered drinking water is compliant with EU quality standards.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	82.0
% leakage rate water distribution system	40.0
Drinking water consumption (m^3/cap/year)	58.4
Drinking water consumption (litres/cap/day)	162

BUCHAREST-ILFOV

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 3.9M€

0 — 300M€

Population directly affected: 56 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2, regions and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

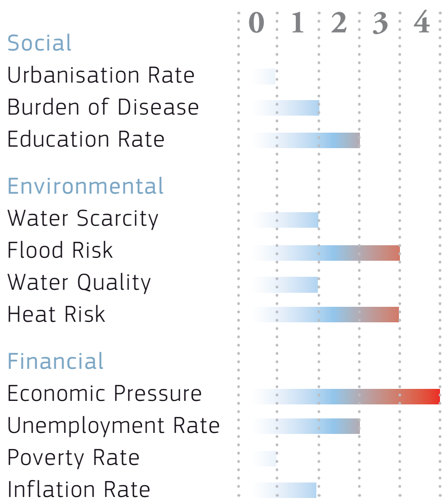
WASTEWATER

The percentage of the population covered by adequate wastewater collection and treatment is 82%. It is a system of combined sewers with only a very small fraction dedicated to storm water. Therefore, the separation of infrastructure is only 1.2%. The average age of the waste water system is unknown. The wastewater discharged into the system is subject to tests, which show it to be in compliance with the relevant standards.

% population connected to at least secondary wastewater treatment	21.0
% population connected to tertiary wastewater treatment	0.0
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	0.0
Average age of sewer (years)	50
% sewer with separated stormwater and sanitary water	1.0

TRENDS & PRESSURES

1.7

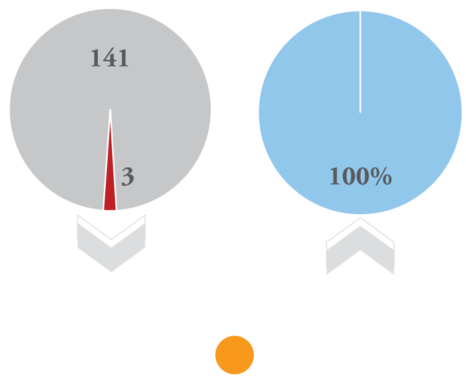


Within this table, lower numbers are better.

Night street scene in Bucharest old city.
© Creative Lab / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



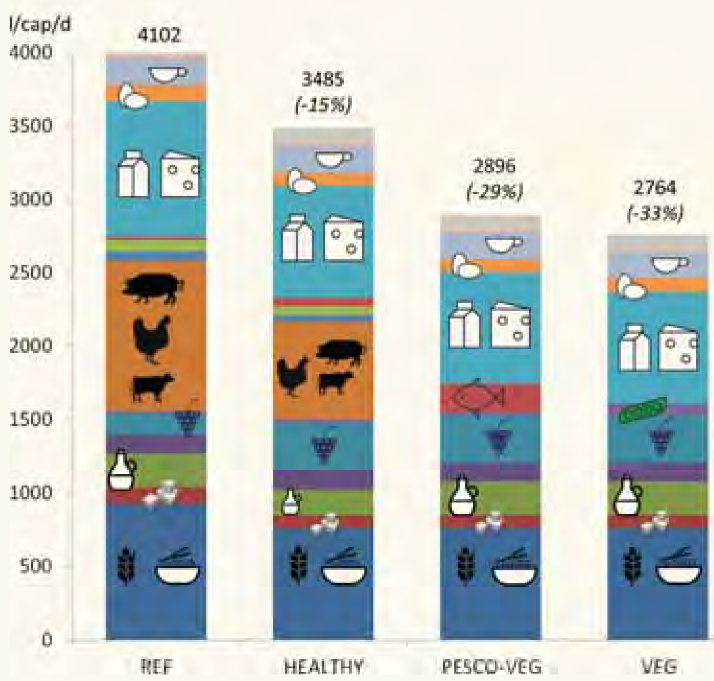
ALERT: 0 WARNING: 3 WATCH: 0

Stress incidents for drought level

BUCHAREST

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



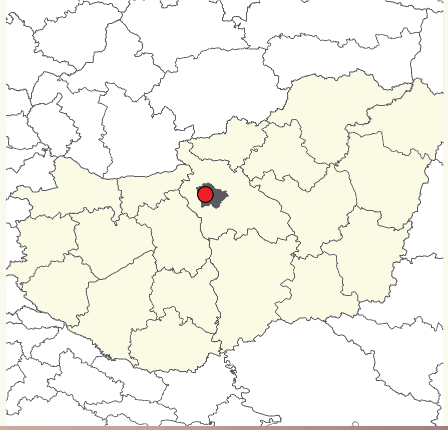
This figure shows the water footprint (WF) related to food consumption for Bucharest. Four diet scenarios are shown. The current diet of the inhabitants of Bucharest leads to a WF of 4 102 l/cap/d, an amount that exceeds the direct water use of the city (58.4 m^3/cap/year which equals 162 l/cap/d) substantially. A healthy diet, as recommended by national Romanian dietary guidelines (Ghid pentru Alimentația Sanatoasa), leads to a WF of 3 485 l/cap/d, so a reduction of 15%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 29% reduction to 2 896 l/cap/d) and a vegetarian diet (a 33% reduction to 2 764 l/cap/d). Bucharest's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

Budapest

47°29'52" N | 19°02'23" E   *Country: Hungary, Region: Central Hungary*

National Flag   City Flag   Coat of Arms



Hungarian parliament in Budapest during sunrise. © Rudy Balasko / Shutterstock.com

BUDAPEST

Budapest, capital of Hungary, was formed in the late 19th century with the merging of three cities, Pest, Buda and Óbuda, although its history goes back more than 1 000 years. It is the cultural, political and transport centre of Hungary, and an emerging financial hub of Central Europe. Nature is protected in two national parks and several conservation areas.
Budapest is the largest city of Hungary and one of the largest of the EU, and is growing with a population estimated at 1 742 000 in 2014, inward migration exceeds outward migration.
The city lies in the centre of the Carpathian-Danube Basin, and is the only capital city in the world with its own thermal springs.
Budapest has a humid continental climate with cold winters, frequent heavy snowfalls and warm summers, often with heavy showers.

ENVIRONMENTAL QUALITY

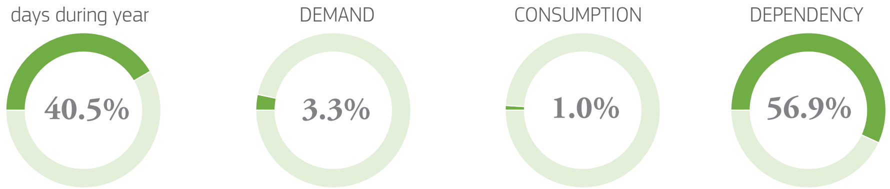
In Budapest, 60% of vehicle journeys are made using public transport, while the remaining 40% are in private cars and other transport modes. These figures show the increasing importance of public transportation. The city is continually improving its selective waste-collection system, separating plastic, glass, metal and paper (but not organic waste). Awareness campaigns are widespread. Budapest is a member of the Covenant of Mayors, and as such it follows a sustainable-energy action plan to go beyond EU energy policy objectives. Wastewater treatment has improved significantly in the last decade.

Resident population (x 1 000)	1 745
Population density (inhabitants/km²)	3 322
kg/cap/year Waste production	250
% Recycling and composting	22
% Incineration with energy recovery	0
% Landfill	67

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year   W.E.I. DEMAND   W.E.I. CONSUMPTION   Water DEPENDENCY



Evapotranspiration difference (**mm/y**)

BUDAPEST

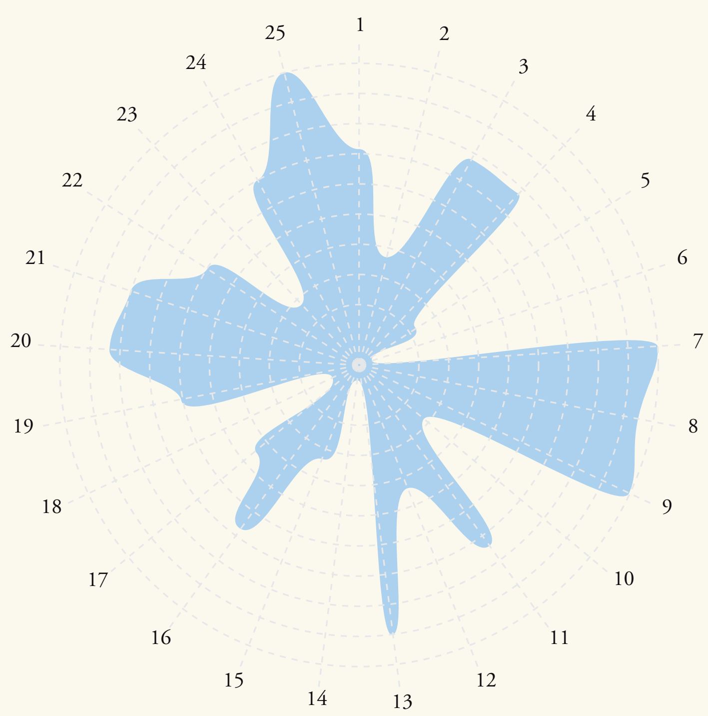
CITY BLUEPRINT ©

Budapest has developed its climate adaptation policy and has a low water consumption and low water leakages. Yet, investments in infrastructure refurbishment, solid-waste treatment and the inclusion of blue-green areas are recommended.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **4.7**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	7.1
2	Tertiary WWT	3.7
3	Groundwater Quality	7.9
4	Solid Waste Collected	7.9
5	Solid Waste Recycled	2.2
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.4
9	Drinking Water Quality	10.0
10	Nutrient Recovery	2.8
11	Energy Recovery	7.1
12	Sewage Sludge Recycling	4.3
13	WWT Energy Efficiency	9.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	3.2
16	Water System Leakages	6.8
17	Stormwater Separation	4.4
18	Green Space	0.9
19	Climate Adaptation	6.0
20	Drinking Water Consumption	8.2
21	Climate Robust Buildings	8.0
22	Management and Action Plans	6.0
23	Public Participation	2.7
24	Water Efficiency Measures	7.0
25	Attractiveness	10.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Panoramic view of Budapest, Hungary. © Brian Kinney

WATER BASICS

Budapest is built on water, with its rich network of streams and medicinal water around and under the city, which is traversed by the great River Danube. Some 125 springs produce 70 million litres of thermal water a day, with temperatures up to 58°C. The cleanliness of water is ensured by the unusual geology and natural filtering effect of Szentendrei-sziget, an extensive island in the Danube from which much of the city's water supply is abstracted.

Annual average rainfall (mm)	620
Daily average air temperature (°C)	10.0
% of blue and green area	18.8
% of soil sealed	63.6
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	17.6

DRINKING WATER

The average daily water use in Budapest is 667 000 m³, increasing to 800 000 m³ in the summer season. The main source of potable water is from boreholes in the Szentendrei island, which abstract water originating from the Danube, but filtered through sand and gravel forming the island. The drinking water quality is generally high, with detailed monitoring proving full compliance with national and EU standards.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	16.0
Drinking water consumption (m³/cap/year)	84.9
Drinking water consumption (litres/cap/day)	236

WASTEWATER

The sewer system of the city is 5 657 km long. 51% of wastewater generated in dry periods is treated at the North-Pest and South-Pest plants, jointly achieving a capacity of 235 000 m³/day. The South-Pest treatment plant has a biological treatment capacity of 80,000 m³/day and a nutrient removal capacity of 80 000 m³/day.The North-Pest plant treats 155 000 m³/day on average, but sometimes reaching 200 000 m³/day.

% population connected to at least secondary wastewater treatment	71.0
% population connected to tertiary wastewater treatment	37.0
% wastewater that is treated with nutrient-recovering techniques	40.0
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	70
% sewer with separated stormwater and sanitary water	44.0

Szechenyi Baths in Budapest in Hungary on a sunny day. © posztos / Shutterstock.com:

HUNGARY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 408%

2036-2065 415%

2066-2095 392%

0 600%

Average % change in population directly affected

2006-2035 731%

2036-2065 667%

2066-2095 686%

0 750%

CENTRAL HUNGARY

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 29.4 M€

0 300M€

Population directly affected: 56 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

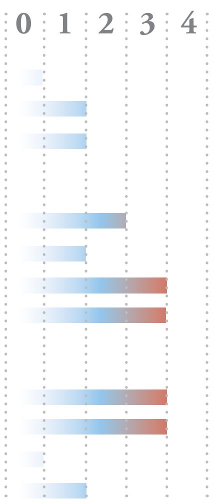
TRENDS & PRESSURES

1.7

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

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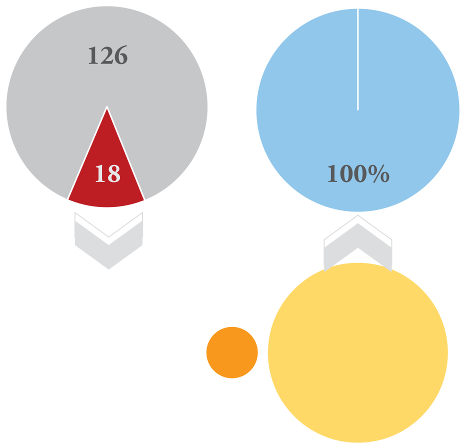
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



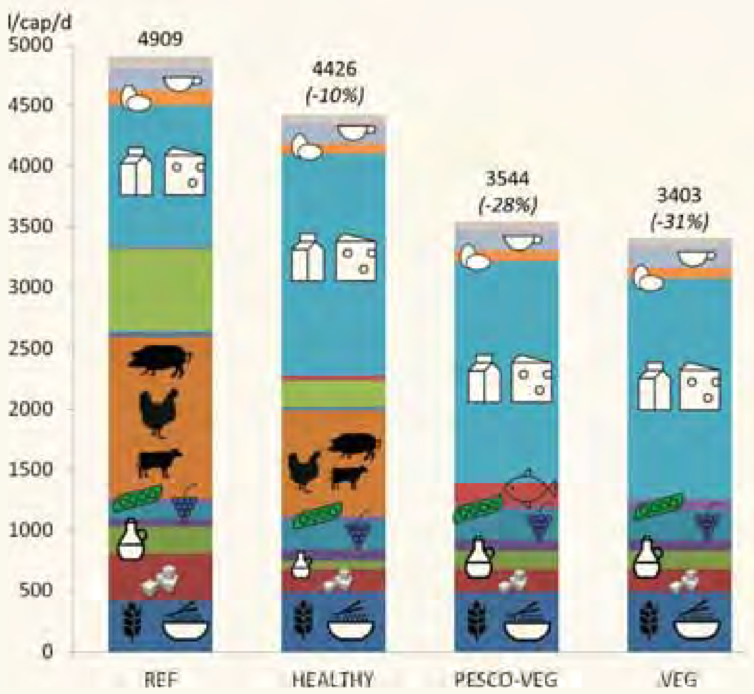
ALERT: 0 WARNING: 4 WATCH: 14

Stress incidents for drought level

BUDAPEST

WATER FOOTPRINT

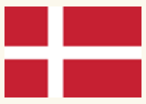
- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Budapest. Four diet scenarios are shown. The current diet of the inhabitants of Budapest leads to a WF of 4 909 l/cap/d, an amount that exceeds the direct water use of the city (84.9 m³/cap/year which equals 236 l/cap/d) substantially.
A healthy diet, as recommended by national dietary guidelines, leads to a WF of 4 426 l/cap/d, so a reduction of 10%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 28% reduction to 3 544 l/cap/d) and a vegetarian diet (a 31% reduction to 3 403 l/cap/d). Budapest's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

Copenhagen



National Flag

Coat of Arms

55°40′33″ N | 12°33′55″ E Country: Denmark, Region: Zealand

Nyhavn Canal. © Mapics / Shutterstock.com | Below: People ridding bicycles in Copenhagen, with Christiansborg palace on background. © William Perugini / Shutterstock.com

COPENHAGEN

Copenhagen is the capital and most populated city of Denmark, with an urban population of 522 000 and a wider metropolitan population of about 1.3 million. The city is mostly on the island of Zealand, but extends to the smaller island of Amager. It is the country's main business and financial centre, and has a high number of international company headquarters and distribution centres. Copenhagen is one of Europe's most sustainable cities, with the highest ranking in the Siemens Green City Index. Successive governments, at national and municipal levels, have strongly promoted sustainable development, of which its position as having the world's highest rate of bicycle ownership is an example.

Resident population (x 1 000)	522
Population density (inhabitants/km²)	6 607
Waste production kg/cap/year	720
% Recycling and composting	43
% Incineration with energy recovery	54
% Landfill	3

ENVIRONMENTAL QUALITY

Copenhage's initiatives and ambitions to promote a cleaner and sustainable environment are recognised by its selection as EU Green Capital 2014. Its commitments include to become the most bicycle-friendly city, for its harbour and waterways to be clean enough for bathing, and to become the world's first carbon-neutral city by 2025. A district scheme supplies 97% of the city with clean, reliable and affordable heating. It captures waste heat from electricity production and channels it back to homes. In addition to significantly cutting household bills, this saves the equivalent of 200 000 tonnes of oil per year. A programme to promote green roofs helps capture rainfall and air pollution.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year	W.E.I. DEMAND	W.E.I. CONSUMPTION	Water DEPENDENCY
43.3%	1.7%	0.7%	11.2%

Evapotranspiration difference (mm/y)

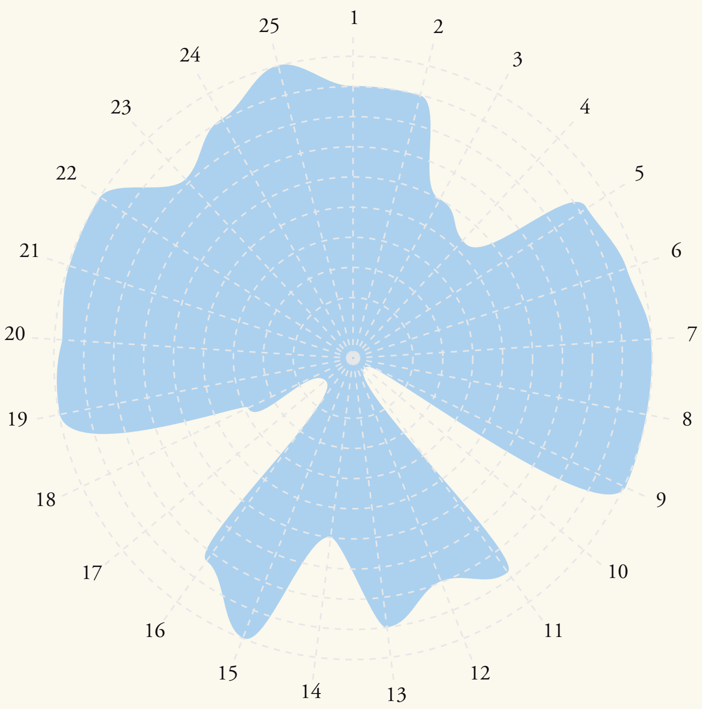
591.6

COPENHAGEN

CITY BLUEPRINT ©

Copenhagen has high indicator scores. However, more blue-green infrastructure and stormwater separation could improve flood vulnerability. Also solid-waste production is high and nutrient recovery from wastewater is lacking.

The BCI (Blue City Index) is 7.1



Nr.	Indicator	Score
1	Secondary WWT	8.8
2	Tertiary WWT	8.6
3	Groundwater Quality	5.7
4	Solid Waste Collected	5.2
5	Solid Waste Recycled	9.5
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	8.8
12	Sewage Sludge Recycling	7.9
13	WWT Energy Efficiency	9.0
14	Average Age Sewer	6.0
15	Operation Cost Recovery	10.0
16	Water System Leakages	8.4
17	Stormwater Separation	1.2
18	Green Space	3.9
19	Climate Adaptation	10.0
20	Drinking Water Consumption	9.8
21	Climate Robust Buildings	10.0
22	Management and Action Plans	10.0
23	Public Participation	8.1
24	Water Efficiency Measures	9.0
25	Attractiveness	10.0

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is 7.1

derivative reproduction from original CITY BLUEPRINT (TM)

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Buildings along Peblinge Bridge at night, in Copenhagen, Denmark. © ESB Professional / Shutterstock.com

WATER BASICS

Being located on an island means water is very much a part of Copenhagen's character, and provides bathing and boating popular leisure activities for its inhabitants. The city has set up more than 60 drinking fountains (some seasonal) to provide free high-quality drinking water for inhabitants and tourists on the move. Water also supports a sustainable public transport system with harbour busses contributing to the network.

Annual average rainfall (mm)	640
Daily average air temperature (°C)	8.0
% of blue and green area	28.5
% of soil sealed	47.0
% flooded by 1-m sea-level rise	26.0
% flooded by 1-m river-level rise	18.6

DRINKING WATER

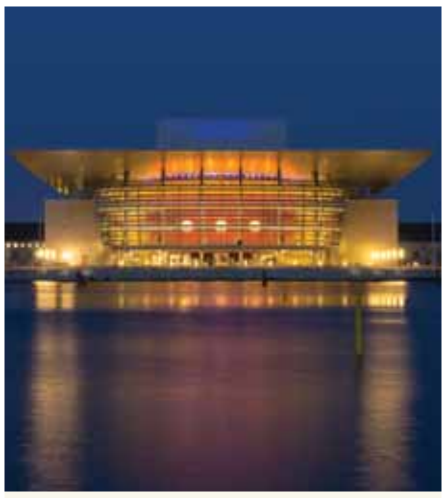
As for all of Denmark, 100% of supply originates from groundwater, in order to protect more sensitive surface water bodies, and because groundwater typically requires much less treatment. 100% of the population is supplied with safe drinking water. The dedication to a high quality and reliable water supply is reflected in Denmark having the highest supply costs in the world, which consumers are generally content to pay.

% of drinking water samples complying with drinking water regulation	92
% urban population with access to potable drinking water	100
% leakage rate water distribution system	8.0
Drinking water consumption (m^3/cap/year)	49.6
Drinking water consumption (litres/cap/day)	138

WASTEWATER

Advanced wastewater management and treatment has been key to cleaning up Copenhagen's harbour waters. 85% of the population is connected to wastewater infrastructure. There is no nutrient recovery, but 100% relies on recovered energy for treatment. The average infrastructure age is 30 years, of which 12% is a combined system.

% population connected to at least secondary wastewater treatment	87.9
% population connected to tertiary wastewater treatment	85.6
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	100
Average age sewer (years)	30
% sewer with separated stormwater and sanitary water	12.0



Opera house of Copenhagen.
© Dmitry Polonskiy / Shutterstock.com

COPENHAGEN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 9%

2036-2065 -18%

2066-2095 76%

-30 0 400%

Average % change in population directly affected

2006-2035 5%

2036-2065 -10%

2066-2095 89%

-30 0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DENMARK

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 0 M€

0 300M€

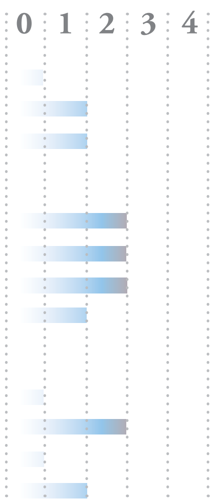
Population directly affected: 0 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

1.1



Social
Urbanisation Rate
Burden of Disease
Education Rate

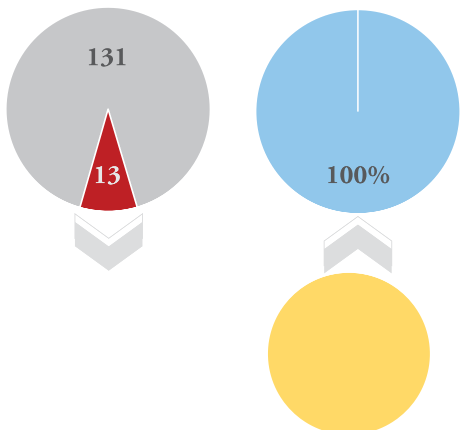
Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate

Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



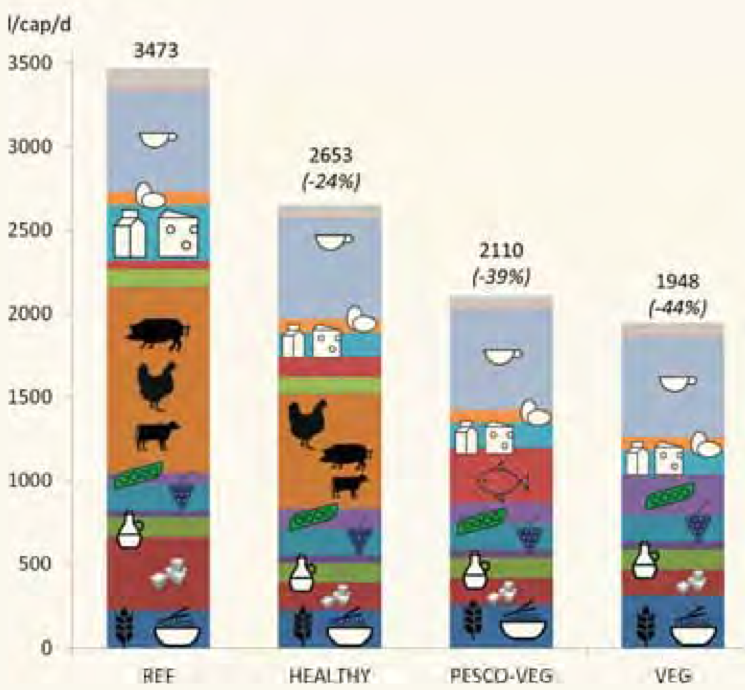
ALERT: 0 WARNING: 0 WATCH: 13

Stress incidents for drought level

COPENHAGEN

WATER FOOTPRINT

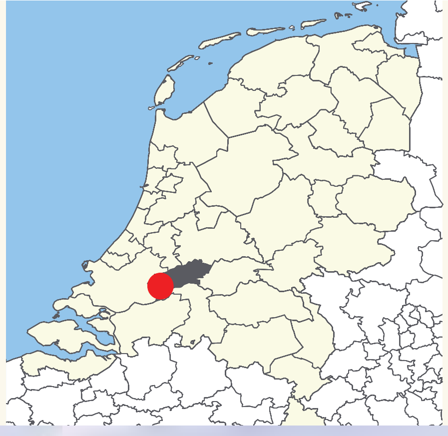
- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Copenhagen. Four diet scenarios are shown. The current diet of the inhabitants of Copenhagen leads to a WF of 3 473 l/cap/d, an amount that exceeds the direct water use of the city (49.6 m^3/cap/year which equals 138 l/cap/d) substantially. A healthy diet including meat, as recommended by the Danish Food Administration (Fødevarestyrelsen), leads to a WF of 2 653 l/cap/d, so a reduction of 24%. Even greater reductions in the WF are observed for a healthy pesco-vegetarian diet (a 39% reduction to 2 110 l/cap/d) and a vegetarian diet (a 44% reduction to 1 948 l/cap/d). Copenhagen's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

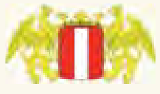


Dordrecht

51°48′36″ N | 4°40′24″ E   *Country: The Netherlands, Region: South Holland*

National Flag

City Flag



Coat of Arms

Marina with boats in the old city center with the old church. © www.hollandfoto.net / Shutterstock.com | Below: evening light at the river Merwede in Dordrecht. © Daan Kloeg / Shutterstock.com

DORDRECHT

Dordrecht is a municipality in the western Netherlands, situated in the province of South Holland. Geographically, Dordrecht covers the entire Dordrecht Island, also often called Het Eiland van Dordt, bordered by the rivers Oude Maas, Beneden Merwede, Nieuwe Merwede, Hollands Diep, and Dordtsche Kil. Dordrecht is the oldest city in the Holland region, and has a rich history and culture. Dordrecht is the Netherland's sixth largest sea port.
Its current economy is based on ship building, and the wood and steel industries.
Dordrecht has a moderate maritime climate influenced by the North Sea and the warm Gulf Stream. Winters are mild and summers not too hot, but extremes in weather and temperatures may occur. Precipitation is evenly spread over the year, with occasional winter snowfall.

ENVIRONMENTAL QUALITY

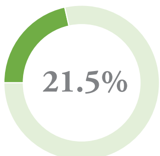
Dordrecht is adjacent to the Biesbosch ('sedge forest') National Park, two parts of which, the Sliedrechtse Biesbosch and the Dordtse Biesbosch, lie within the municipality, forming the Hollandse Biesbosch. It is one of the largest national parks in the Netherlands. and one of the last extensive freshwater tidal areas in north west Europe.
The municipality pays much attention to the natural environment and actively promotes wind energy installations. To this purpose, the city encourages a proactive dialogue with its citizens.
Dordrecht owes its existence to its favourable location on the water, but with the result that water safety and storm protection are top municipal priorities.

Resident population (x 1 000)	119
Population density (inhabitants/km²)	1 193
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

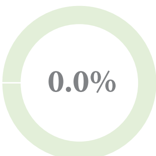
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

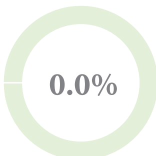
% SOIL WATER STRESS days during year



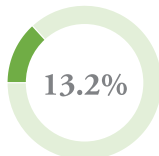
W.E.I. DEMAND



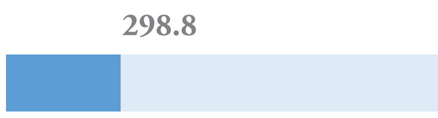
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



DORDRECHT

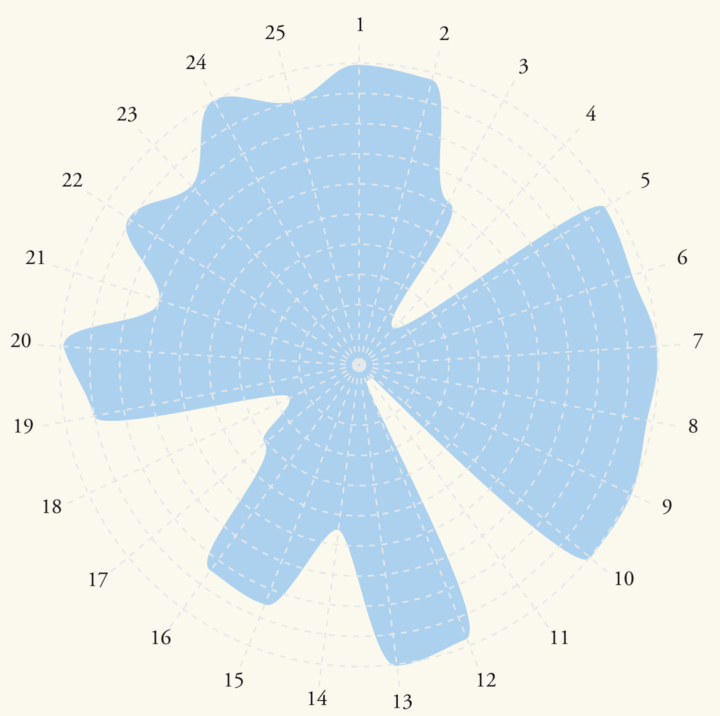
CITY BLUEPRINT ©

Dordrecht excels in climate change adaptation and flood protection. The city can improve by investing in blue-green infrastructure, recovering energy from wastewater and reducing solid-waste production.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **7.0**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	6.1
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	9.9
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	9.9
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	5.4
15	Operation Cost Recovery	8.5
16	Water System Leakages	8.4
17	Stormwater Separation	4.0
18	Green Space	2.6
19	Climate Adaptation	9.0
20	Drinking Water Consumption	9.9
21	Climate Robust Buildings	7.0
22	Management and Action Plans	9.0
23	Public Participation	8.1
24	Water Efficiency Measures	10.0
25	Attractiveness	9.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Panorama of the river Merwede at Dordrecht at sunset in evening light in Zuid-Holland, The Netherlands. © Daan Kloeg / Shutterstock.com

WATER BASICS

Sited on a low-lying island in the south east of the South Holland province, where the Merwede River becomes the Noord and Oude Maas, Dordrecht has a history of flooding. Resilient building and defences have been built over the centuries, including a complex dyke system, but some areas still experience flooding. Climate change is projected to create an additional threat to the city.

Annual average rainfall (mm)	802
Daily average air temperature (°C)	10.0
% of blue and green area	24.3
% of soil sealed	44.4
% flooded by 1-m sea-level rise	100
% flooded by 1-m river-level rise	80.3

DRINKING WATER

Drinking water in Dordrecht is provided by the Evides Water Company. As for all of the Netherlands, the water is of very high quality. The city of Dordrecht has no specific policy on drinking water. It has a mix of raw water sources, including 80% surface water (from the River Maas), 16% groundwater and 4% high quality dune water.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	8.0
Drinking water consumption (m^3/cap/year)	47.4
Drinking water consumption (litres/cap/day)	132

WASTEWATER

Having reached the end of its technical life, Dordrecht's wastewater treatment plant was recently renovated to address rising maintenance costs and to meet environmental requirements. Improvements included: conversion from a semi-open to a closed process; capture of released gases; optimising chemical consumption; better sludge quality and operational cost savings.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	0.0
Average age of sewer (years)	33
% sewer with separated stormwater and sanitary water	40.0

Dordrecht seen form above.
© Chantal de Bruijne / Shutterstock.com

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 229%

2036-2065 22%

2066-2095 296%

0 400%

Average % change in population directly affected

2006-2035 255%

2036-2065 42%

2066-2095 340%

0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SOUTH HOLLAND

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 255M€

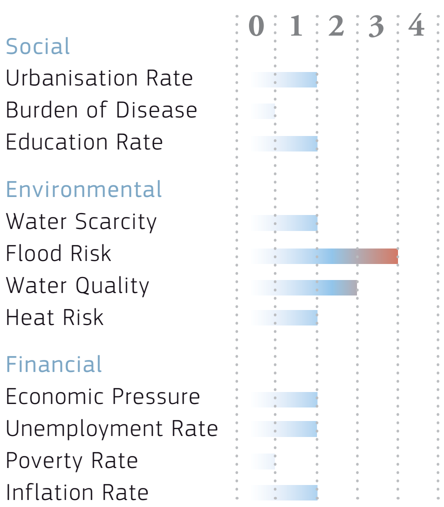
0 300M€

Population directly affected: 19028 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

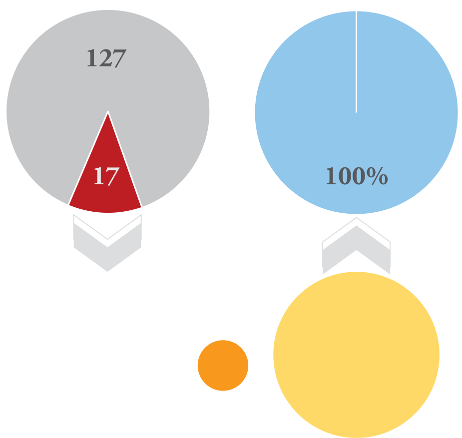
TRENDS & PRESSURES



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



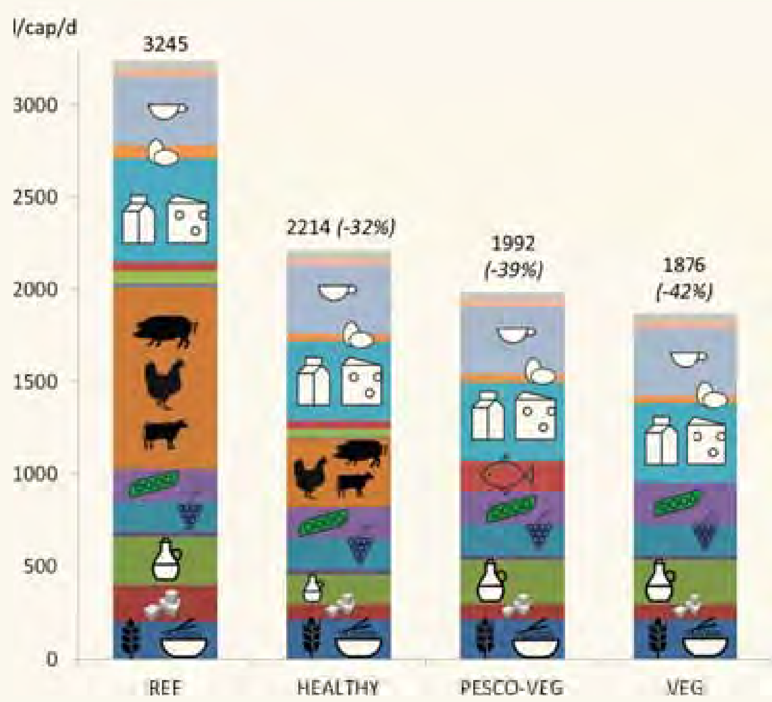
ALERT: 0 WARNING: 4 WATCH: 13

Stress incidents for drought level

DORDRECHT

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Dordrecht. Four diet scenarios are shown. The current diet of the inhabitants of Dordrecht leads to a WF of 3 245 l/cap/d, an amount that exceeds the direct water use of the city (47.4 m^3/cap/year which equals 132 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2 214 l/cap/d, so a reduction of 32%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 39% reduction to 1 992 l/cap/d) and a vegetarian diet (a 42% reduction to 1 876 l/cap/d). Dordrecht's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

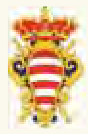
References:
Vanham D, Mak TN, Gawlik BM (2016) Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565: 232–239.

Dubrovnik

42°38'53" N | 18°05'31" E *Country: Croatia, Region: Dalmatia*

National Flag

City Flag



Coat of Arms

Panorama of old town of Dubrovnik in Croatia. © Ajan Alen / Shutterstock.com | Below: Stradun, popular pedestrian street in Dubrovnik, Croatia. © Microgen / Shutterstock.com

DUBROVNIK

Dubrovnik is a Croatian city on the Adriatic Sea, in the region of Dalmatia. It is a prominent tourist destination of the Mediterranean, a seaport and the population centre of Dubrovnik-Neretva County. Its total population is 42 615. The city's historic prosperity was based on maritime trade, supporting a high level of development, particularly during the 15th and 16th centuries, as it became notable for its wealth and skilled diplomacy.
Dubrovnik lies between a humid subtropical and Mediterranean climate. It has hot, moderately dry summers and mild, wet winters. The Bura wind blows uncomfortably cold gusts down the Adriatic coast between October and April, and thundery conditions are common all year round, even in summer, when they can interrupt the warm, sunny days.

Resident population (x 1 000)	43
Population density (inhabitants/km^2)	297

ENVIRONMENTAL QUALITY

Dubrovnik has one of the oldest environmental codes, dating back to the 13th century. This code is manifested in decisions on paving the streets, determining their slope for drainage, and the provisions for the construction and maintenance of septic tanks and sewers with the aim of combatting the historical risks of plague, cholera and other communicable diseases.
The Neretva Delta (of a river which flows mostly through Bosnia-Herzogovina) is one of the most important environmental features of the region, recognised as a Ramsar wetland, but also important for agriculture. A mostly marshland region, with occasional limestone areas, the river and delta are the habitat of one of the largest species of trout, the marble trout.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year	W.E.I. DEMAND	W.E.I. CONSUMPTION	Water DEPENDENCY
39.2%	1.7%	0.9%	0.0%

Evapotranspiration difference (**mm/y**)

298.8

© Phant: Fort St. John. Dubrovnik. Croatia.

Resident Population and Population Density data: EUROSTAT, 2014

Traditional Mediterranean Old Town houses with red tiled roofs and rocky green idyllic island in background. © Youproduction / Shutterstock.com

WATER BASICS

The basic feature of the Dubrovnik-Neretva County is the karst limestone aquifers (characterised by large cave systems) which supply important freshwater springs, providing most of the municipal water supply requirements via the Ombla River. Groundwater quality is generally very good, with occasional problems of turbidity and bacteriological contamination as a result of heavy rainfall after dry periods, not unusual for karst systems.

Annual average rainfall (mm)	1 298
Daily average air temperature (°C)	15.0

DRINKING WATER

Drinking water is of very good quality, and comes mostly from the Ombla river, one of the world's shortest at just 30 m length, 5 km north east of Dubrovnik. Its flow is from springs of the karstic aquifers. Dubrovnik has a main water reservoir and a pumping station to fill high zone water tanks (totally 2 000 m^3 capacity) to supply the higher areas. Due mostly to tourism, there is a large difference between winter and summer water demand.

WASTEWATER

Across Dubrovnik-Neretva County the degree of connection to public sewage systems varies greatly, being highest in Dubrovnik city at 70%. A particular problem is poor rainwater drainage due to the poor and neglected state of the storm water system (partly because of its age), and the high percentage of impermeable street paving, especially in the Old Town. Even medium intensity rain can lead to street flooding.

Fortification wall of old city. © Natalia Paklina / Shutterstock.com

CROATIA

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 72%

2036-2065 190%

2066-2095 151%

0 400%

Average % change in population directly affected

2006-2035 83%

2036-2065 186%

2066-2095 168%

0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

Dubrovnik Old Town roofs at sunset. © Mila Atkovska / Shutterstock.com

ADRIATIC CROATIA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 1.8M€

0 300M€

Population directly affected: 224 inh.

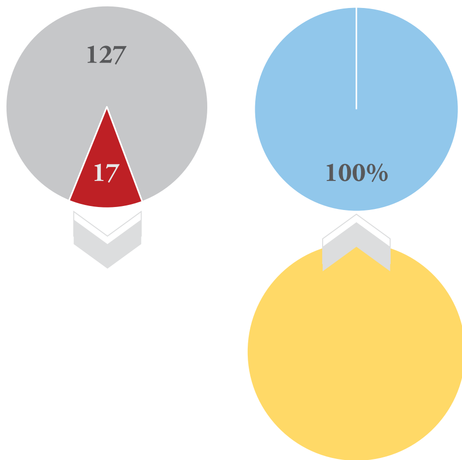
0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

Sunny day over the bay in front of old town of Dubrovnik. © nomadFra / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



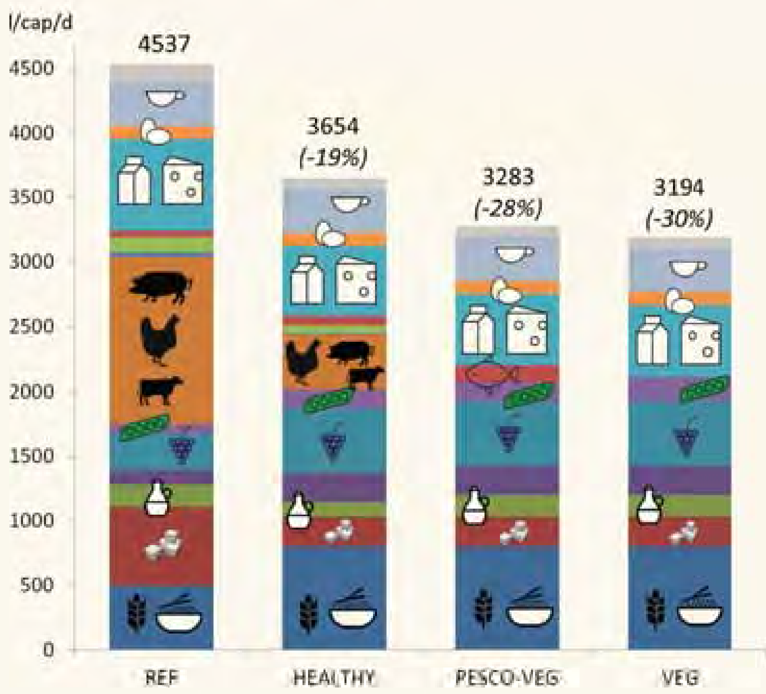
ALERT: 0 WARNING: 0 WATCH: 17

Stress incidents for drought level

DUBROVNIK

WATER FOOTPRINT

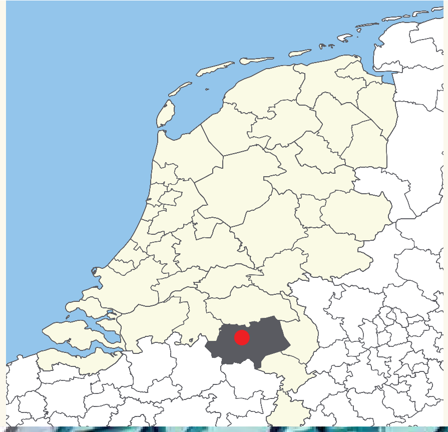
- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Dubrovnik. Four diet scenarios are shown. The current diet of the inhabitants of Dubrovnik leads to a WF of 4 537 l/cap/d. A healthy Mediterranean diet leads to a WF of 3 654 l/cap/d, so a reduction of 19%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 28% reduction to 3 283 l/cap/d) and a vegetarian diet (a 30% reduction to 3 194 l/cap/d). Dubrovnik's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105



Eindhoven

51°26′26″ N | 5°28′40″ E   *Country: The Netherlands, Region: North Brabant*


National Flag


City Flag


Coat of Arms


People walking in the Eindhoven square. © Alex Tihonovs / Shutterstock.com | Below: Escalator to a bicycle parking. © Christian Mueller / Shutterstock.com

EINDHOVEN

Eindhoven is a major city in the province of Noord Brabant in the south Netherlands. With a population of over 213 000, it is the 5th largest city, and the 2nd largest economy of the country. The Eindhoven region is widely regarded as one of Europe's high tech hotspots, and where the international Philips electronics company was founded.
Eindhoven was originally built on sandy elevations between the rivers Dommel, Gender and Tongelreep. The rivers have been heavily modified over the course of time, and today, plans are ongoing to restore, at least partially, the original river courses.
Eindhoven has a mild humid temperate climate with warm summers and no specific dry season. Moderate rain is the most common precipitation usually observed, during 62% of precipitation days.

Resident population (x 1 000)	221
Population density (inhabitants/km²)	2 486
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

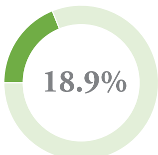
ENVIRONMENTAL QUALITY

The municipality of Eindhoven focuses on continuous improvement of energy efficiency, environmental protection, noise reduction and other aspects of sustainable urban living. The city aims to ensure that, by 2020, 95% of the waste generated by households is re-used or recycled. It also plans to introduce an LED lighting system in which each light can be controlled individually, thus presenting itself as an example of a smart city. Eindhoven also addresses climate mitigation in its urban planning by including water management in building design, implementing measures against heat islands and promoting water retention areas and green roofs to reduce storm run-off and flooding.

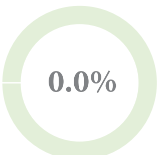
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

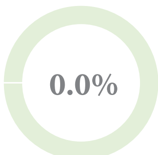
% SOIL WATER STRESS days during year



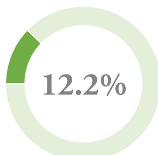
W.E.I. DEMAND



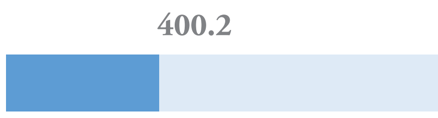
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



EINDHOVEN

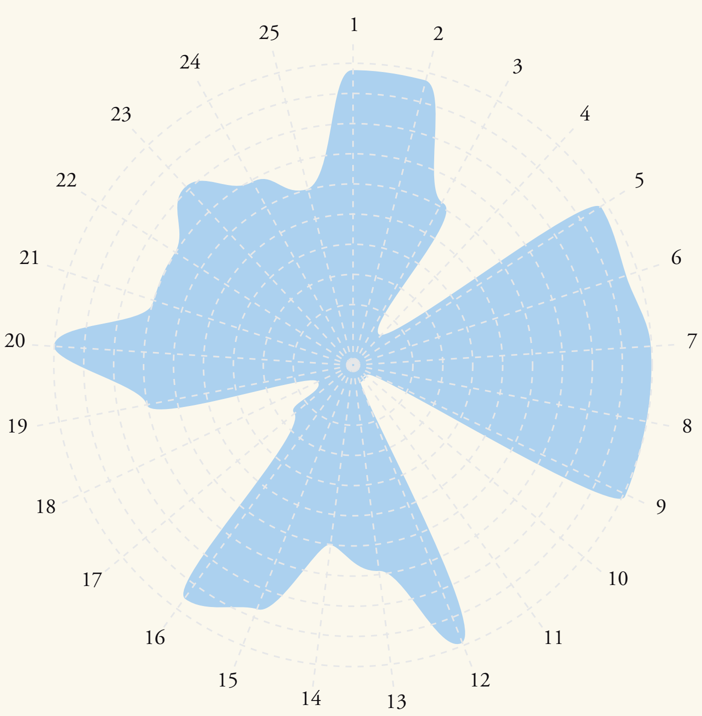
CITY BLUEPRINT ©

Eindhoven's low levels of drinking water consumption and infrastructure leakages is outstanding. Nevertheless, energy and nutrient recovery from wastewater is lacking, and improving blue-green infrastructure may limit its vulnerability to extreme rainfall events.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **5.8**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	6.1
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	9.9
13	WWT Energy Efficiency	7.0
14	Average Age Sewer	6.0
15	Operation Cost Recovery	8.5
16	Water System Leakages	9.5
17	Stormwater Separation	3.0
18	Green Space	1.3
19	Climate Adaptation	7.0
20	Drinking Water Consumption	10
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.0
23	Public Participation	8.1
24	Water Efficiency Measures	7.0
25	Attractiveness	6.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Beautiful art project at the GLOW 2015 light festival in Eindhoven, The Netherlands, on November 11, 2015. © Dennis van de Water / Shutterstock.com

WATER BASICS

There is a close cooperation between different players in the urban water cycle, including the council, the water authority and the water supply company. An important challenge is flood risk from occasional heavy rain, which causes inundation of roads. The storm water capacity of the sewers is limited, and there is a lack of retention capacity in the surface water systems, and poor infiltration capacity of the ground due to high groundwater tables.

Annual average rainfall (mm)	700
Daily average air temperature (°C)	9.0
% of blue and green area	20.2
% of soil sealed	59.5
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	22.1

DRINKING WATER

The water supplier is Brabant Water, servicing businesses and around 2.4 million people, across the province of Noord Brabant. As in the rest of the Netherlands, the drinking water network is very sensitively managed so as to mostly avoid the need for chlorination. This reduces the presence of trihalomethanes (a chlorination by-product) and provides consumers with water that is free of the taste or smell of chlorine.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	2.5
Drinking water consumption (m^3/cap/year)	45.2
Drinking water consumption (litres/cap/day)	126

WASTEWATER

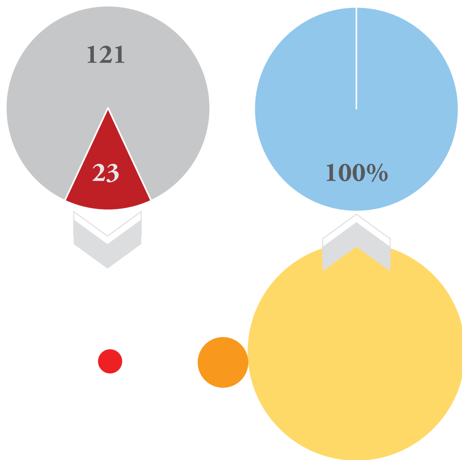
The River Dommel receives discharges from the wastewater treatment plant (WWTP), with a capacity of 750 000 PE (population equivalent) and from over 200 combined sewer overflows, which typically overflow after rains. In summer, the WWTP outflows represent up to 50% of river flow, whose quality does not yet meet the requirements of the EU Water Framework Directive. Investments to improve the situation are ongoing.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	0.0
Average age sewer (years)	30
% sewer with separated stormwater and sanitary water	30.0

The Vesteda tower.
© Alex Tihonovs / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 2 WARNING: 4 WATCH: 17

Stress incidents for drought level

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 229%

2036-2065 22%

2066-2095 296%

0 400%

Average % change in population directly affected

2006-2035 255%

2036-2065 42%

2066-2095 340%

0 550%

NORTH BRABANT

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 8.5M€

0 300M€

Population directly affected: 911 inh.

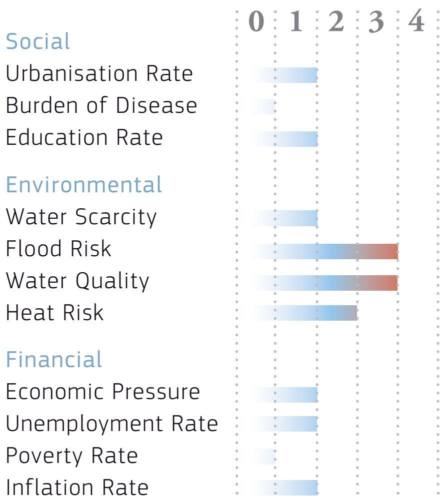
0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

TRENDS & PRESSURES

1.1

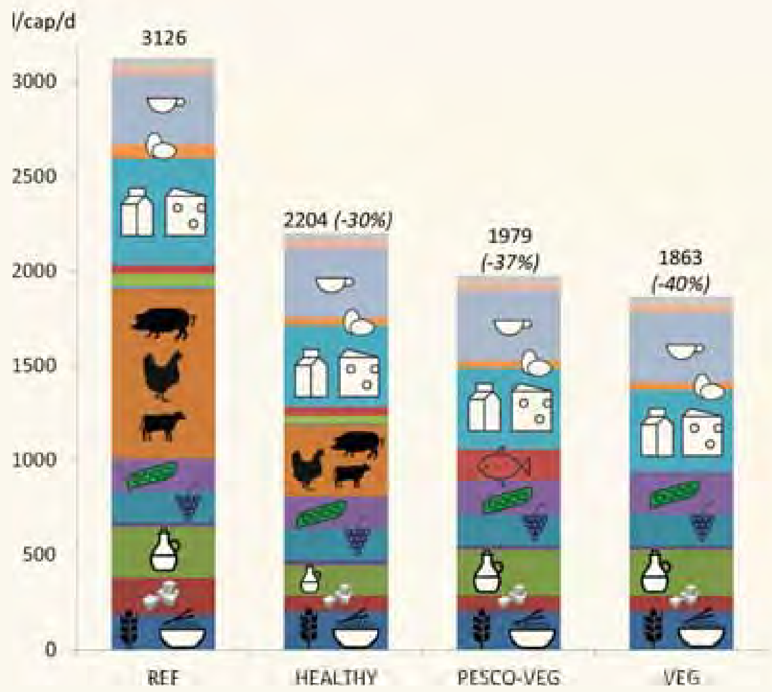


Within this table, lower numbers are better.

EIDNHOVEN

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Eindhoven. Four diet scenarios are shown. The current diet of the inhabitants of Eindhoven leads to a WF of 3 126 l/cap/d, an amount that exceeds the direct water use of the city (45.2 m^3/cap/year which equals 126 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2 204 l/cap/d, so a reduction of 30%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 37% reduction to 1 979 l/cap/d) and a vegetarian diet (a 40% reduction to 1 863 l/cap/d). Eindhoven's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565, 232–239

Eslöv

55°50′21″ N | 13°18′14″ E *Country: Sweden, Region: Skane Region*

National Flag

Coat of Arms

The historic Trolleholm castle situated near the swedish town of Eslov. © Antony McAulay / Shutterstock.com | Below: Hjularod slott castle in Eslov Municipality. © Antony McAulay / Shutterstock.com

ESLÖV

Eslöv Municipality (Eslövs kommun) is one of 290 municipalities of Sweden, situated in Skåne County in southern Sweden, with a population of 32 210. It is part of the Øresund Region, a transnational (Denmark-Sweden) metropolitan area. Today, Eslöv largely serves as a suburb of Lund and Malmö, and is considered part of Greater Malmö since 2005.
In the early 19th century Eslöv was a small village, but started to grow when its railway station was opened on the main line between Stockholm and Malmö in 1858.

The municipality has several interesting places, including 11 castles. Sweden's only sugar refinery lies in Örtofta, south of Eslöv.
Being in the southernmost part of Sweden, Eslöv has an oceanic climate and its summer is much warmer and drier than in other places at a similar latitude.

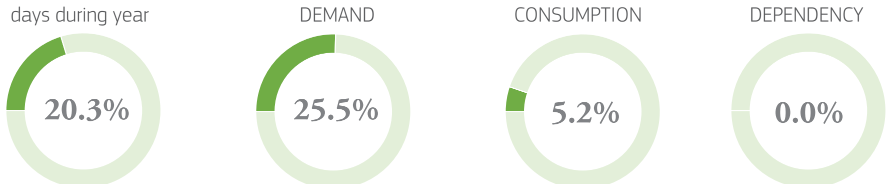
Resident population (x 1 000)	32
Population density (inhabitants/km²)	77
Waste production kg/cap/year	460
% Recycling and composting	47
% Incineration with energy recovery	51
% Landfill	1

ENVIRONMENTAL QUALITY

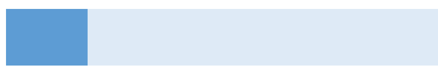
Eslöv Municipality is one of the country's 89 eco-municipalities, which means it has adopted a set of sustainability principles guide municipal policy, and has committed to a bottom-up, participatory approach to implementation. Over 25% of cities and towns in Sweden have adopted and implemented these principles throughout their municipal operations and larger communities.
The city is seen as an attractive and popular place to live, not least because of the good train communications with other parts of Skåne and with Copenhagen. Eslöv benefits from the tranquillity of a small town, close to pleasant countryside, but also offering access to cultural acttractions and modern infrastructure.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



Evapotranspiration difference (**mm/y**)

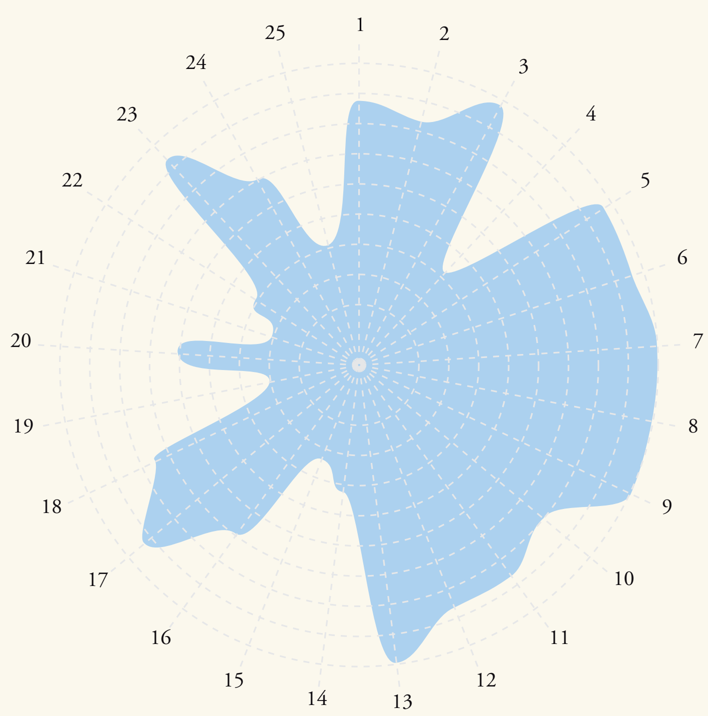


ESLÖV

CITY BLUEPRINT ©

Eslov's wastewater and solid-waste treatment is more than adequate.
The opportunities to improve the urban water management are mainly in developing long-term climate adaptation plans and water conservation.

The BCI (Blue City Index) **is 6.9**



Nr.	Indicator	Score
1	Secondary WWT	8.7
2	Tertiary WWT	8.3
3	Groundwater Quality	9.8
4	Solid Waste Collected	4.1
5	Solid Waste Recycled	9.6
6	Solid Waste Energy Recovered	9.6
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	8.0
11	Energy Recovery	8.7
12	Sewage Sludge Recycling	8.7
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	4.2
15	Operation Cost Recovery	3.3
16	Water System Leakages	7.0
17	Stormwater Separation	9.3
18	Green Space	7.5
19	Climate Adaptation	3.0
20	Drinking Water Consumption	6.0
21	Climate Robust Buildings	3.0
22	Management and Action Plans	4.0
23	Public Participation	9.2
24	Water Efficiency Measures	7.0
25	Attractiveness	4.0

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).
The Blue City Index is **6.9**

derivative reproduction from original CITY BLUEPRINT (TM)

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Image of a half-timbered farmhouse. Ortofta, Sweden. © Sophie McAulay / Shutterstock.com

WATER BASICS

Eslöv is some 20 km from the coast and has no significant river. The nearest significant water bodies are the two lakes of Ringsjön, 10 km to the east. These lakes provide a backup water supply in the event of a failure of the main supply from Lake Bolmen. The temperature ranges from 1.8°C in February up to 16.4°C in the month of July.

Annual average rainfall (mm)	630
Daily average air temperature (°C)	7.0
% of blue and green area	40.0
% of soil sealed	36.0
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	11.0

DRINKING WATER

Like the rest of west Skåne county, Eslöv receives water of high quality from Lake Bolmen, which is more than 100 km away. It goes via the Ringsjön water treatment plant (operated by Sydvatten AB), about 6 km north east of Eslöv. From Lake Bolmen, the water is first transported through an 80-km-long tunnel, taking around eight days, after which it is transported along a final 25 km pipeline, before it reaches the treatment plant.

% of drinking water samples complying wth drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	15.0
Drinking water consumption (m^3/cap/year)	133.5
Drinking water consumption (litres/cap/day)	371

WASTEWATER

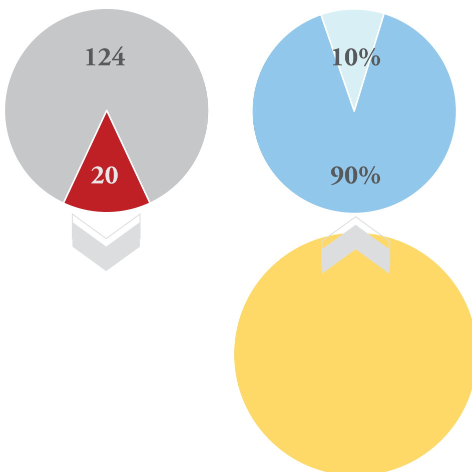
Eslöv is served by the Ellinge WWT plant just to the south of the town and serving 19 000 people including nearby communities. Biogas is produced by anaerobic digestion of sewage sludge and biological waste. Of the biogas produced, three-quarters provides heating for the WWTP facilities and nearby homes, and the remainder goes to a nearby vehicle filling station.

% population connected to at least secondary wastewater treatment	87.0
% population connected to tertiary wastewater treatment	83.0
% wastewater that is treated with nutrient-recovering techniques	92.0
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	39
% sewer with separated stormwater and sanitary water	93.0

Ellinge slott castle.
© Antony McAulay / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 0 WARNING: 0 WATCH: 19

Stress incidents for drought level

SWEDEN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	37%
2036-2065	25%
2066-2095	90%
0	400%

Average % change in population directly affected

2006-2035	31%
2036-2065	12%
2066-2095	68%
0	550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SOUTH SWEDEN

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 12M€

0 — 300M€

Population directly affected: 287 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

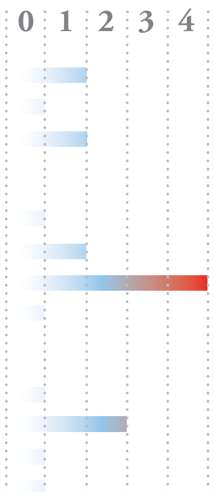
TRENDS & PRESSURES

0.8

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate

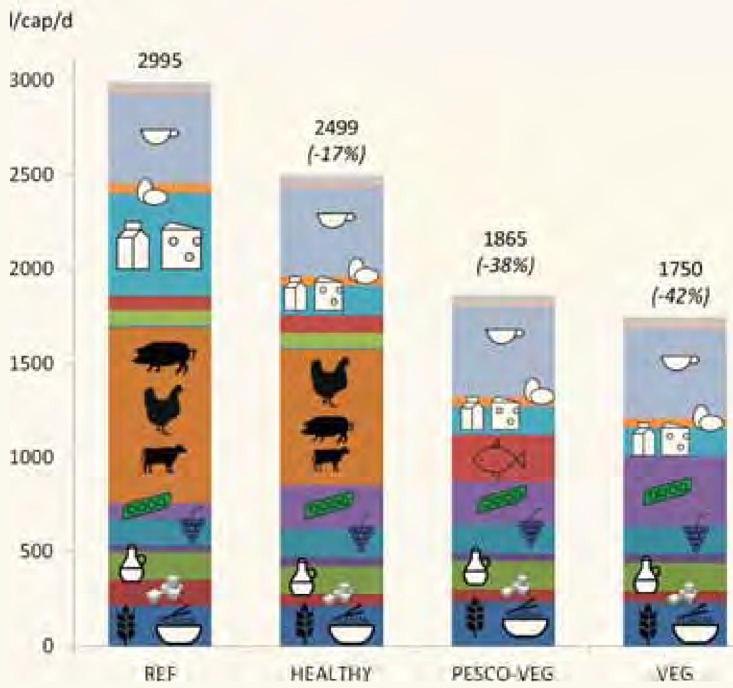


Within this table, lower numbers are better.

ESLÖV

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Eslöv. Four diet scenarios are shown. The current diet of the inhabitants of Eslöv leads to a WF of 2 995 l/cap/d, an amount that exceeds the direct water use of the city (133.5 m^3/cap/year which equals 371 l/cap/d) substantially. A healthy diet, as recommended by the Swedish National Food Agency (Livsmedelsverket), leads to a WF of 2 499 l/cap/d, so a reduction of 17%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 38% reduction to 1 865 l/cap/d) and a vegetarian diet (a 42% reduction to 1 750 l/cap/d). Eslöv's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

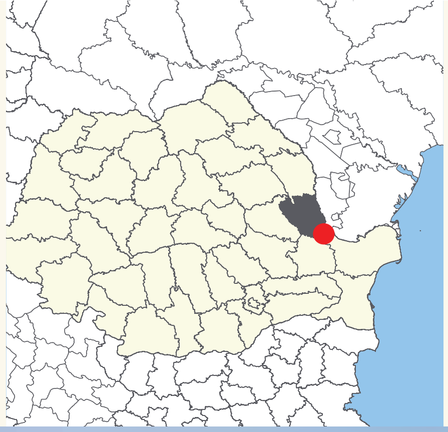
References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

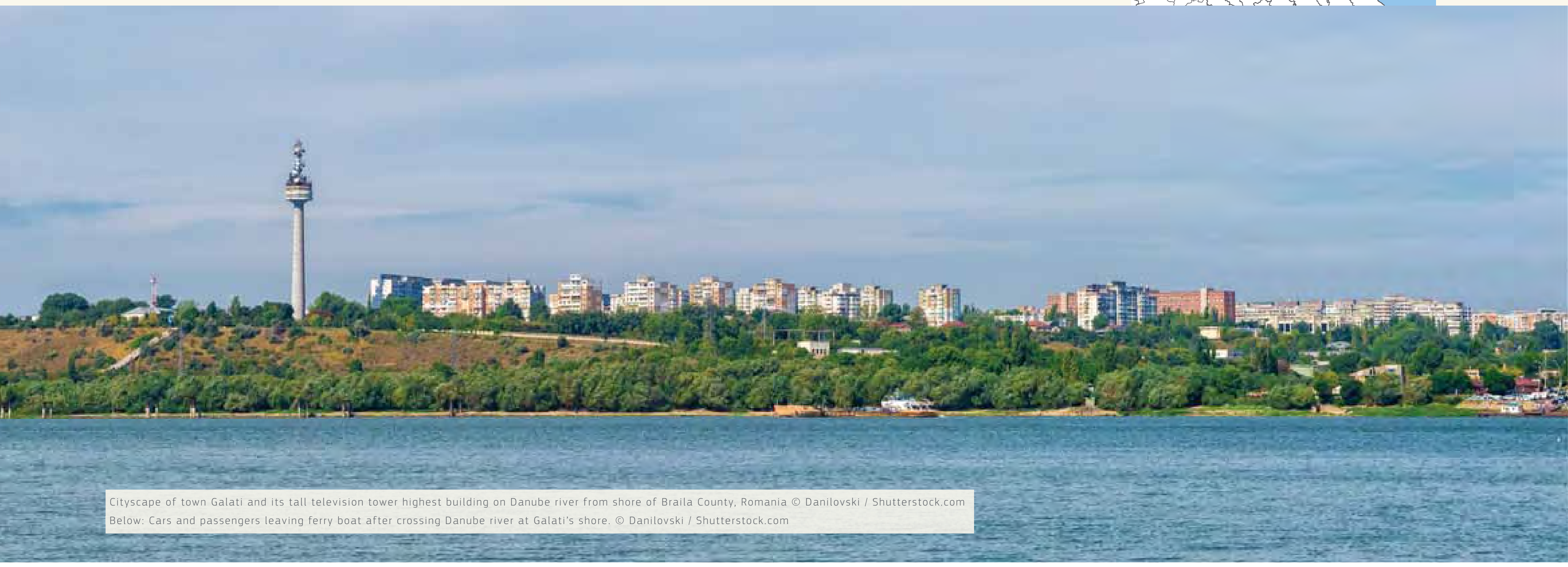
Galați

45°27′00″ N | 28°03′00″ E   *Country: Romania, Region: Moldavia*

National Flag

Coat of Arms





Cityscape of town Galati and its tall television tower highest building on Danube river from shore of Braila County, Romania © Danilovski / Shutterstock.com
Below: Cars and passengers leaving ferry boat after crossing Danube river at Galati's shore. © Danilovski / Shutterstock.com

GALATI

Galați is a historical port town in eastern Romania and a major economic centre on the Danube River. It has approximately 250 000 inhabitants. Principal economic activities are centred on the naval shipyard, steel industry and mineral exports. It lies on the left bank of the Danube, at the junction of the Siret and Prut rivers. Galați comes under the influence of eastern continental air masses, less from the south and is almost totally lacking influence of weather systems from the west. The city experiences an average of only 66 days of precipitation a year, and severe weather is rare. Spring and summer thunderstorms occur irregularly and are brief. Galați is one of the largest commercial traffic hubs in Romania, connected to the main European communication corridors.

Resident population (x 1 000)	285
Population density (inhabitants/km^2)	1 158
Waste production kg/cap/year	329
% Recycling and composting	5
% Incineration with energy recovery	0
% Landfill	95

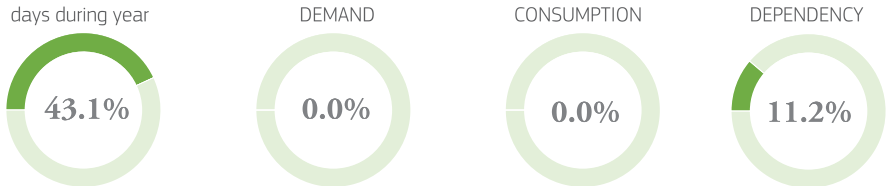
ENVIRONMENTAL QUALITY

Galați actively promotes a policy to improve environmental quality for its citizens. While being an area of strong economic development, burdens from the past remain a major concern for citizens. The municipality has improved its urban waste management system, and Galați now ranks among the top cities in Romania for public green spaces, representative of the importance given to sustainable urban living. The urban planning and maintenance in Galați have generated a gradual improvement of the city's overall environmental quality since Romania's joining of the European Union in 2007.

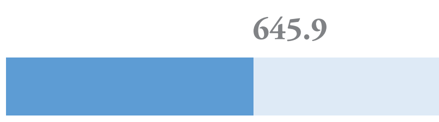
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year | W.E.I. DEMAND | W.E.I. CONSUMPTION | Water DEPENDENCY



Evapotranspiration difference **(mm/y)**



GALAȚI

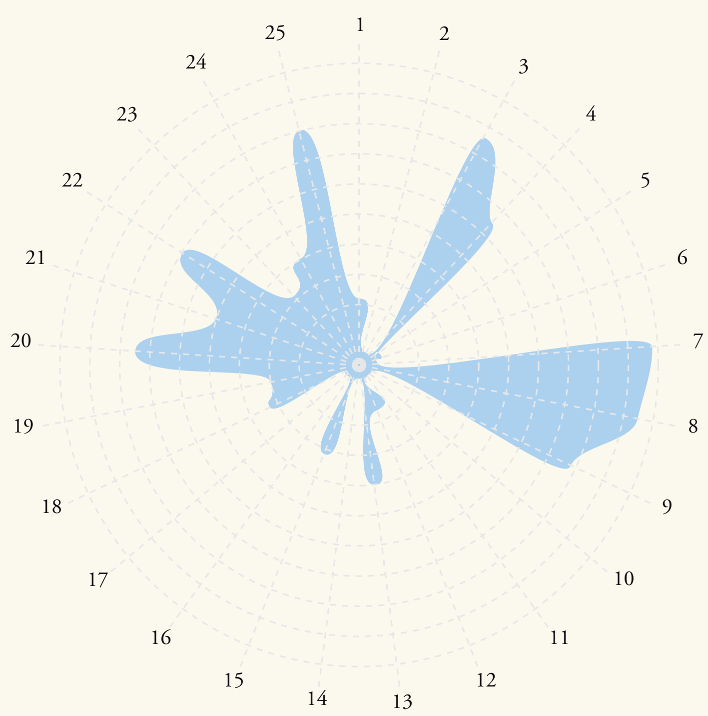
CITY BLUEPRINT ©

Galați performs well with respect to its reduced water consumption and low solid waste production. The city faces serious challenges regarding wastewater treatment, infrastructure refurbishment and solid-waste treatment.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is 2.4

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	2.1
2	Tertiary WWT	0.0
3	Groundwater Quality	8.7
4	Solid Waste Collected	6.5
5	Solid Waste Recycled	0.5
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	9.8
8	Access to Sanitation	9.4
9	Drinking Water Quality	7.9
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	1.6
13	WWT Energy Efficiency	4.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	3.0
16	Water System Leakages	0.0
17	Stormwater Separation	0.0
18	Green Space	3.1
19	Climate Adaptation	3.0
20	Drinking Water Consumption	7.5
21	Climate Robust Buildings	5.0
22	Management and Action Plans	7.0
23	Public Participation	3.1
24	Water Efficiency Measures	4.0
25	Attractiveness	8.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Sunset over the Danube in Galati, Romania. © bymandesigns / Shutterstock.com | Below: Propeller monument in Galati in downtown in a cloudy day. © Danilovski / Shutterstock.com

WATER BASICS

Apă Canal S.A. Galați has regional responsibility for the delivery of safe drinking water and wastewater collection and treatment for the entire county of Galați. The main challenges are to improve the existing installations for the production and delivery of drinking water and for the collection, transportation and purification of wastewater.

Annual average rainfall (mm)	477
Daily average air temperature (°C)	10.0
% of blue and green area	26.0
% of soil sealed	63.9
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	5.5

DRINKING WATER

In Galați county, water resources are sufficient to meet the demand for drinking water. The main sources of water are surface water from the Danube and groundwater from deep boreholes. Comprehensive treatment is applied, including chlorination.

% of drinking water samples complying with drinking water regulation	79
% urban population with access to potable drinking water	98.0
% leakage rate water distribution system	51.9
Drinking water consumption (m^3/cap/year)	101.3
Drinking water consumption (litres/cap/day)	281

WASTEWATER

In Galați, the wastewater average flow is about 100 000 m^3/day. The collection system covers an area of 2 300 ha, serving approximately 99% of the population. The basic infrastructure is very old, and was extended along with the expansion of the city. There are several collectors of wastewater and rainwater from various areas with very different characteristics, according to the existing water-pipe drainage system.

% population connected to at least secondary wastewater treatment	21.0
% population connected to tertiary wastewater treatment	0.0
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	0.0
Average age sewer (years)	65
% sewer with separated stormwater and sanitary water	0.0

Queen Elizabeth Park Is One Of The Largest Public Parks Of Tecuci City Of Galati County. © Radu Bercan / Shutterstock.com

ROMANIA

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	140%
2036-2065	147%
2066-2095	134%
0	400%

Average % change in population directly affected

2006-2035	117%
2036-2065	122%
2066-2095	180%
0	550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SUD-EST

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 59 M€

0 — 300M€

Population directly affected: 1234 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

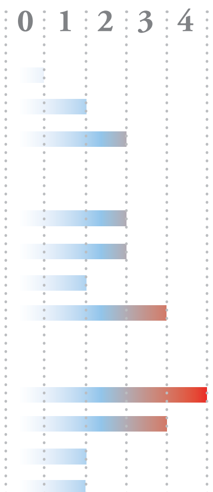
TRENDS & PRESSURES

1.8

Social
- Urbanisation Rate
- Burden of Disease
- Education Rate

Environmental
- Water Scarcity
- Flood Risk
- Water Quality
- Heat Risk

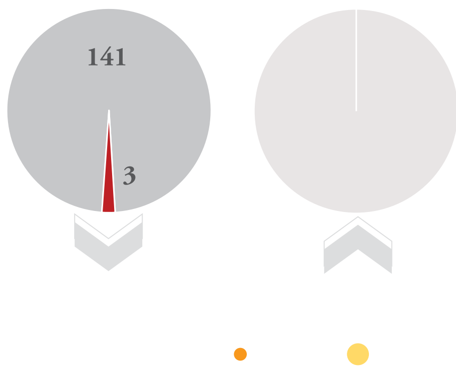
Financial
- Economic Pressure
- Unemployment Rate
- Poverty Rate
- Inflation Rate



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



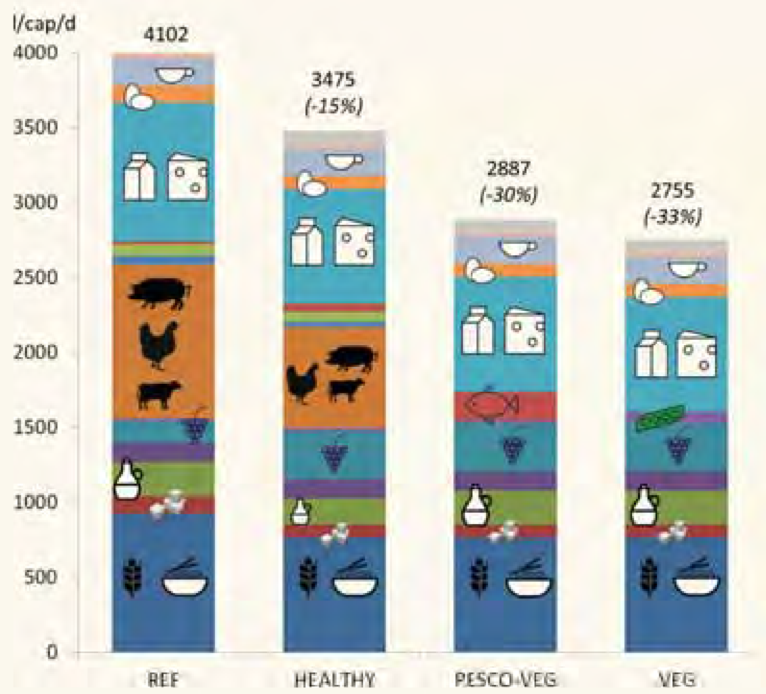
ALERT: 0 WARNING: 1 WATCH: 2

Stress incidents for drought level

GALAȚI

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Galați. Four diet scenarios are shown. The current diet of the inhabitants of Galați leads to a WF of 4 102 l/cap/d, an amount that exceeds the direct water use of the city (101.3 m^3/cap/year which equals 281 l/cap/d) substantially. A healthy diet, as recommended by national Romanian dietary guidelines (Ghid pentru Alimentația Sanatoasa), leads to a WF of 3 475 l/cap/d, so a reduction of 15%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 30% reduction to 2 887 l/cap/d) and a vegetarian diet (a 33% reduction to 2 755 l/cap/d). Galați's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

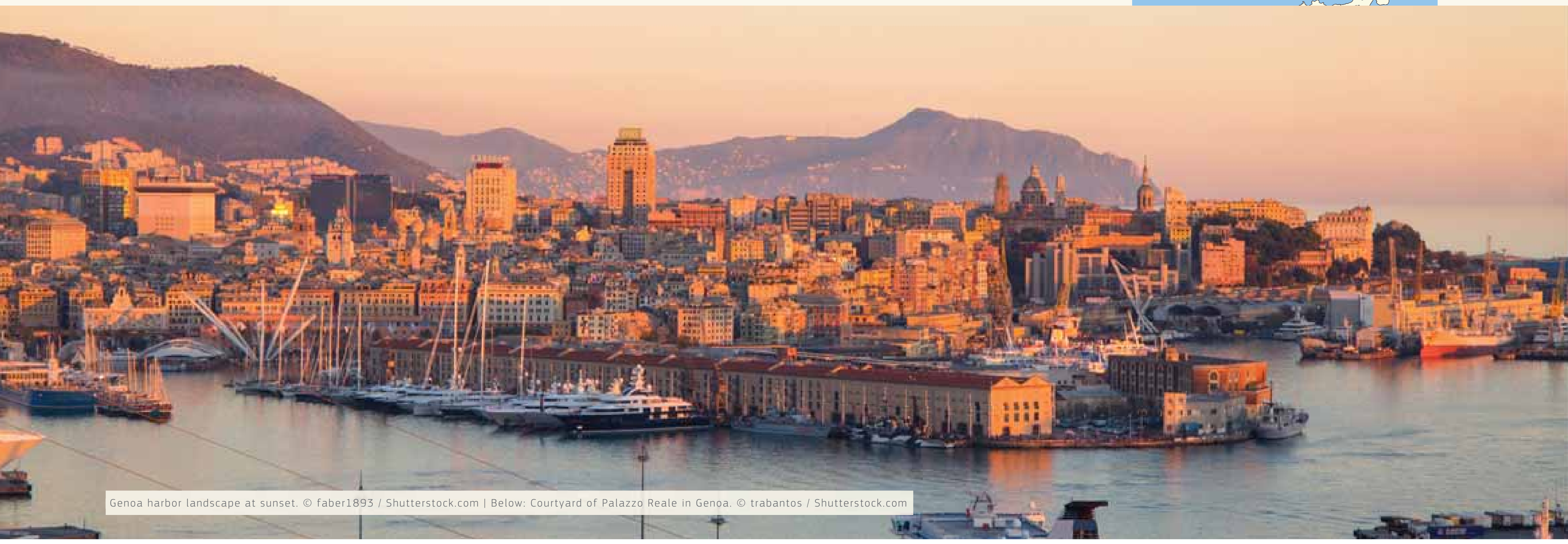
Genoa

44°25′35″ N | 8°54′54″ E   *Country: Italy, Region: Liguria*


National Flag


City Flag


Coat of Arms


Genoa harbor landscape at sunset. © faber1893 / Shutterstock.com | Below: Courtyard of Palazzo Reale in Genoa. © trabantos / Shutterstock.com

GENOA

Genoa is the capital of the Liguria region on the north west Italian coast. Genoa is Italy's largest seaport with a trade volume of 51.6 million tonnes. It is Italy's 6th largest city, and one of the largest European cities on the Mediterranean Sea. Genoa was formerly one of the three major industrial cities of Italy, but nowadays, the many factories have been replaced by commerce, communications, banking, insurance and various other services.
The city is located on the coast, with an average elevation of 20m and features a humid subtropical and Mediterranean climate.
In the coldest months, temperature averages 12°C and during the warmest months, 28°C. Northern winds in winter often bring cool air from the Po Valley, usually accompanied by lower temperatures, high pressure and clear skies.

Resident population (x 1 000)	597
Population density (inhabitants/km²)	2 484
Waste production kg/cap/year	540
% Recycling and composting	34
% Incineration with energy recovery	17
% Landfill	49

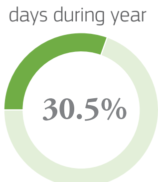
ENVIRONMENTAL QUALITY

Decision-makers of city and province of Genoa are aware of the important role of citizens for environmental policies. There is a comprehensive network to monitor air pollution, inclusive of emissions from shipping.
A major concern is the increased occurrence of flash flooding caused by torrential rains.
The city obviously has a strong relationship with the Mediterranean Sea. The city aquarium, one of the most famous in the world, plays an important role in education.
The city is also active in experimenting with advanced waste collection systems, and has completed trials in the context of the EIP Smart Cities "intelligent bins" within the circular economy initiative "LiguriaCircular", developed in Italy.

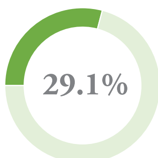
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

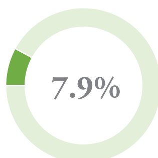
% SOIL WATER STRESS days during year



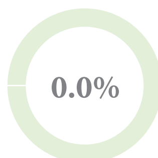
W.E.I. DEMAND



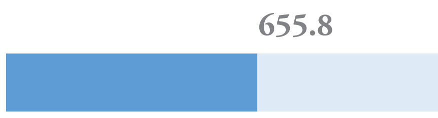
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



GENOA

CITY BLUEPRINT ©

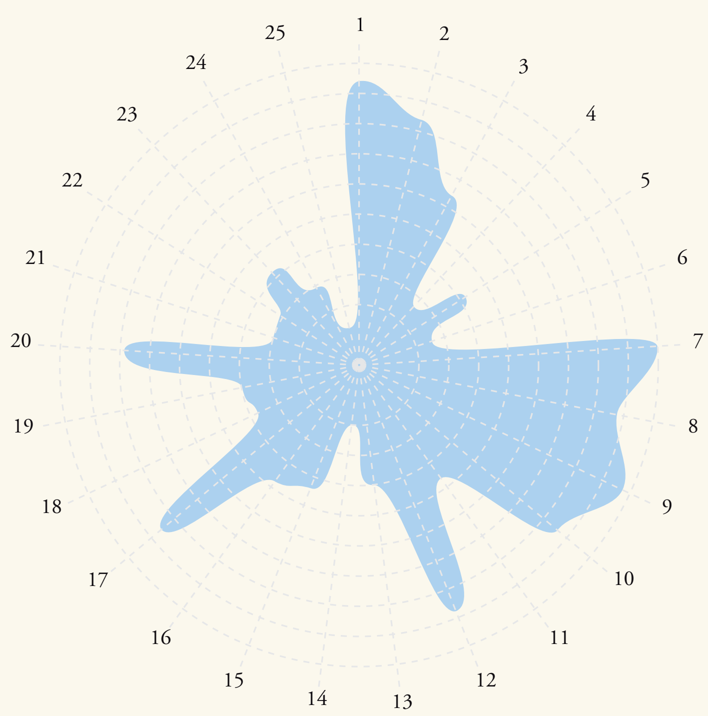
Genoa has an advanced wastewater treatment system, low levels of drinking-water consumption and largely separates stormwater. Solid waste treatment, infrastructure refurbishment and climate change adaptation plans need further attention.

The BCI (Blue City Index) **is 4.9**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **4.9**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.4
2	Tertiary WWT	8.4
3	Groundwater Quality	6.5
4	Solid Waste Collected	2.7
5	Solid Waste Recycled	4.1
6	Solid Waste Energy Recovered	2.6
7	Access to Drinking Water	10.0
8	Access to Sanitation	8.9
9	Drinking Water Quality	9.8
10	Nutrient Recovery	8.7
11	Energy Recovery	4.7
12	Sewage Sludge Recycling	8.8
13	WWT Energy Efficiency	4.0
14	Average Age Sewer	2.0
15	Operation Cost Recovery	4.3
16	Water System Leakages	4.8
17	Stormwater Separation	8.7
18	Green Space	3.8
19	Climate Adaptation	4.0
20	Drinking Water Consumption	8.0
21	Climate Robust Buildings	3.0
22	Management and Action Plans	3.0
23	Public Participation	4.2
24	Water Efficiency Measures	3.0
25	Attractiveness	1.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Square raffaele de ferrari. © trabantos / Shutterstock.com

WATER BASICS

Genoa is challenged with observed changes in climate-driven events: long periods without rain and an increased frequency of flash floods. Genoa and the Liguria region experienced many flooding events in the past ten years.
The water system was designed for more stable climate conditions and less advanced urban development, and is suitable for contemporary conditions and increased variability.

Annual average rainfall (mm)	1 072
Daily average air temperature (°C)	15.6
% of blue and green area	28.2
% of soil sealed	53.9
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	23.5

ITALY

PROJECTED FLOOD RISK

Average % change in economic damage
2006-2035 48%
2036-2065 177%
2066-2095 394%
0 400%

Average % change in population directly affected
2006-2035 105%
2036-2065 283%
2066-2095 515%
0 550%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e., around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DRINKING WATER

Genoa obtains its drinking water from multiple sources, the most important being surface water from the surrounding hills, such as the Brugneto basin. Other important sources are from groundwater.
The drinking water is considered to be of medium to high quality. It requires little treatment, except in the historic centre of the city where the quality is at greater risk due to the age of the infrastructure.

% of drinking water samples complying with drinking water regulation	98
% urban population with access to potable drinking water	100
% leakage rate water distribution system	25.9
Drinking water consumption (m^3/cap/year)	89.6
Drinking water consumption (litres/cap/day)	249

LIGURIA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 0.55 M€
0 300M€

Population directly affected: 56 inh.
0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

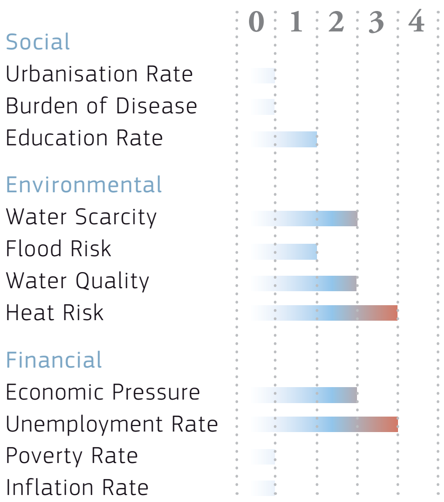
WASTEWATER

Genoa's 1 027-km-long sewer system comprises a total of nine wastewater treatment plants, with eight on the coast. The entire system is controlled remotely with a network of sensors and monitoring mechanisms. As in many older urban areas, it has mostly a combined wastewater system (mixing sewage and stormwater run-off), which puts greater pressures on treatment plants after heavy rains. Some rainwater is discharged directly into the sea.

% population connected to at least secondary wastewater treatment	94.0
% population connected to tertiary wastewater treatment	84.0
% wastewater that is treated with nutrient-recovering techniques	93.0
% wastewater that is treated with energy-recovering techniques	50.0
Average age sewer (years)	50
% sewer with separated stormwater and sanitary water	87.1

TRENDS & PRESSURES

1.4

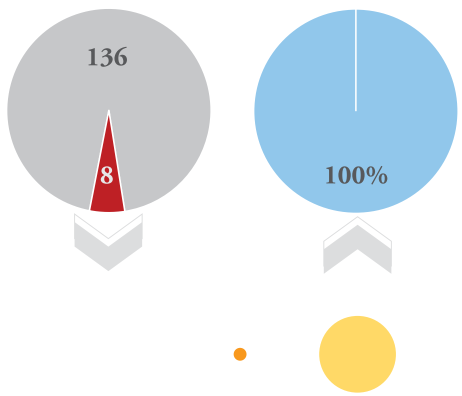


Within this table, lower numbers are better.

View of Genoa, port city in northern Italy.
© Alex Tihonovs / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



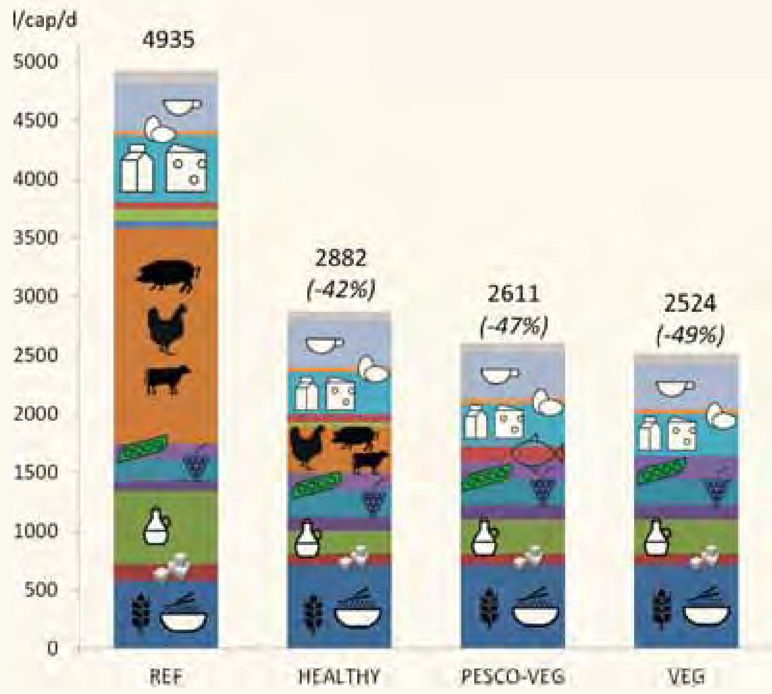
ALERT: 0 WARNING: 1 WATCH: 7

Stress incidents for drought level

GENOA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Genoa. Four diet scenarios are shown. The current diet of the inhabitants of Genoa leads to a WF of 4 935 l/cap/d, an amount that exceeds the direct water use of the city (89.6 m^3/cap/year which equals 249 l/cap/d) substantially. A healthy diet, as recommended by the Italian National Research Institute on Food and Nutrition (INRAN, Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione; Linee guida per una sana alimentazione italiana), leads to a WF of 2 882 l/cap/d, so a reduction of 42%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 47% reduction to 2 611 l/cap/d) and a vegetarian diet (a 49% reduction to 2 524 l/cap/d). Genoa's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

Hamburg

53°34′31″ N | 10°00′55″ E   *Country: Germany, Region: Hamburg Metropolitan*

National Flag   City Flag   Coat of Arms

Hamburg city of warehouses palace at night © Ryszard Filipowicz / Shutterstock.com | Below: Hamburger Landungsbruecken with harbor and traditional paddle steamer on Elbe river, St. Pauli district. © canadastock / Shutterstock.com

HAMBURG

The Free and Hanseatic City of Hamburg, in the north of the country, is Germany's second largest city and the eighth largest in the EU. Hamburg is a port city on the Elbe river, at its confluence with the Alster and Bille rivers. This affluent city is a major industrial and commercial centre and transport hub. The port of Hamburg is the second busiest in Europe (by container numbers) and of key significance for the German economy.
The city has a long tradition as a financial centre and has also become an important media centre. Its geographic and strategic position between Continental Europe and Scandanavia has contributed to its economic success.
Hamburg has an oceanic climate, influenced by its proximity to the coast and marine air masses that originate over the Atlantic.

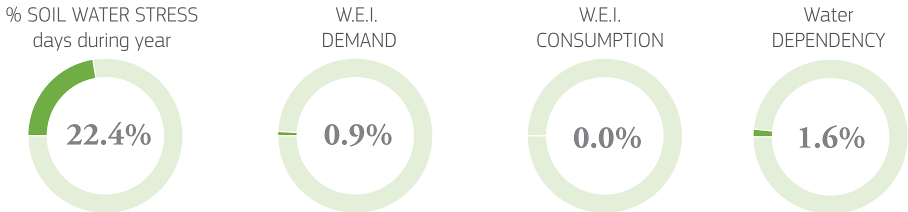
Resident population (x 1 000)	2 050
Population density (inhabitants/km²)	2 312
Waste production kg/cap/year	600
% Recycling and composting	63
% Incineration with energy recovery	16
% Landfill	0

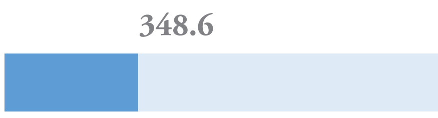
ENVIRONMENTAL QUALITY

The city of Hamburg was awarded the title "European Green Capital 2011" by the EU Commission because of its ambitious targets in sustainability, climate and environmental protection. It was ranked 16th in the world for liveability in Mercer's 2015 survey. Environmental protection is at the heart of Hamburg's policy in urban development, and the citizens' participation and interest for sustainable urban living is very high. Hamburg has made significant efforts to reduce CO_2 emissions, and aims to cut them by 40% from 1990 to 2020, and by 80% from 1990 to 2050. The city also has plans to exploit the heat generating potential of its wastewaters.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index





HAMBURG

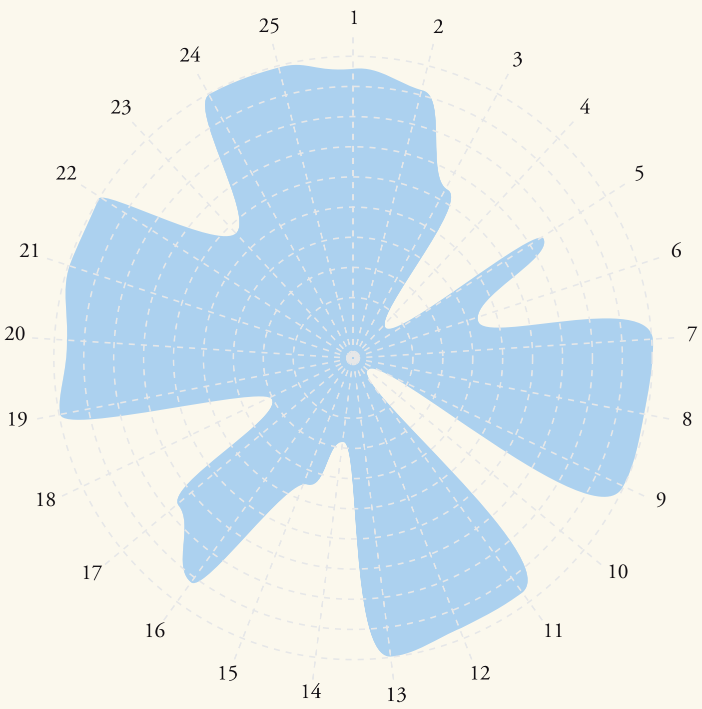
CITY BLUEPRINT ©

Hamburg is leading in climate change adaptation, wastewater treatment and infrastructure leakage reduction. Hamburg can improve with respect to nutrient recovery from wastewater and solid waste production.

The BCI (Blue City Index) **is 6.6**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).
The Blue City Index is **6.6**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.6
2	Tertiary WWT	9.3
3	Groundwater Quality	6.4
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	7.5
6	Solid Waste Energy Recovered	4.3
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	9.6
12	Sewage Sludge Recycling	9.6
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	2.8
15	Operation Cost Recovery	3.3
16	Water System Leakages	9.1
17	Stormwater Separation	7.6
18	Green Space	3.0
19	Climate Adaptation	10.0
20	Drinking Water Consumption	9.7
21	Climate Robust Buildings	10.0
22	Management and Action Plans	10.0
23	Public Participation	5.8
24	Water Efficiency Measures	10.0
25	Attractiveness	10.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Panoramic view of famous Binnenalster (Inner Alster Lake). © canadastock / Shutterstock.com

WATER BASICS

Raw water is drawn exclusively from high-quality groundwater reserves, and requires very little treatment. Water efficiency campaigns have helped reduce the per capita water use to one of the lowest in Europe, at 51.8 m³ per person. Hamburg is investigating and promoting sustainable urban water systems through action research and multi-stakeholder Learning Alliances.

Annual average rainfall (mm)	750
Daily average air temperature (°C)	8.0
% of blue and green area	25.6
% of soil sealed	49.6
% flooded by 1-m sea-level rise	22.1
% flooded by 1-m river-level rise	32.1

DRINKING WATER

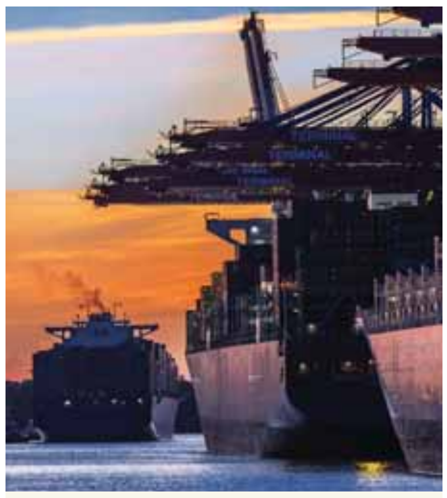
Hamburg has excellent drinking water quality, consistently complying with the requirements of the EU Drinking Water Directive. Regular monitoring ensures quality standards are met and any problems are detected early. Some 30 000 samples for chemical analysis and 27 000 for micro-biological analysis are taken annually from groundwater and drinking water on which more than 600 000 individual tests are carried out.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	4.4
Drinking water consumption (m³/cap/year)	51.8
Drinking water consumption (litres/cap/day)	144

WASTEWATER

Hamburg has a mix of combined sewers and separated sanitary and stormwater sewers. Although the average infrastructure age is relatively high at 46 years, the rate of system blockages is relatively low. Due to the high energy demand of the system, energy reduction and efficiency are a priority. Wastewater is effectively treated and energy and nutrients recovered. All sewage sludge is thermally recycled.

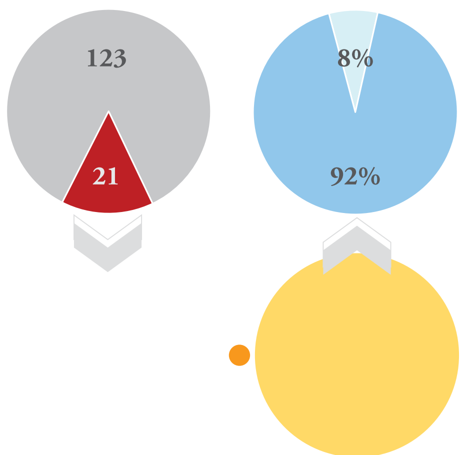
% population connected to at least secondary wastewater treatment	96.3
% population connected to tertiary wastewater treatment	93.4
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	46
% sewer with separated stormwater and sanitary water	76.3



Container Port of Hamburg.
© Gerhard Roethlinger / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 0 WARNING: 2 WATCH: 19

Stress incidents for drought level

GERMANY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	158%
2036-2065	146%
2066-2095	177%
0	400%

Average % change in population directly affected

2006-2035	184%
2036-2065	146%
2066-2095	211%
0	550%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

HAMBURG

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 24 M€

0 — 300M€

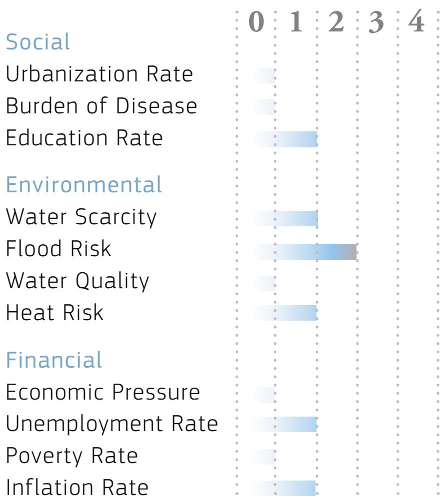
Population directly affected: 2595 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

0.8

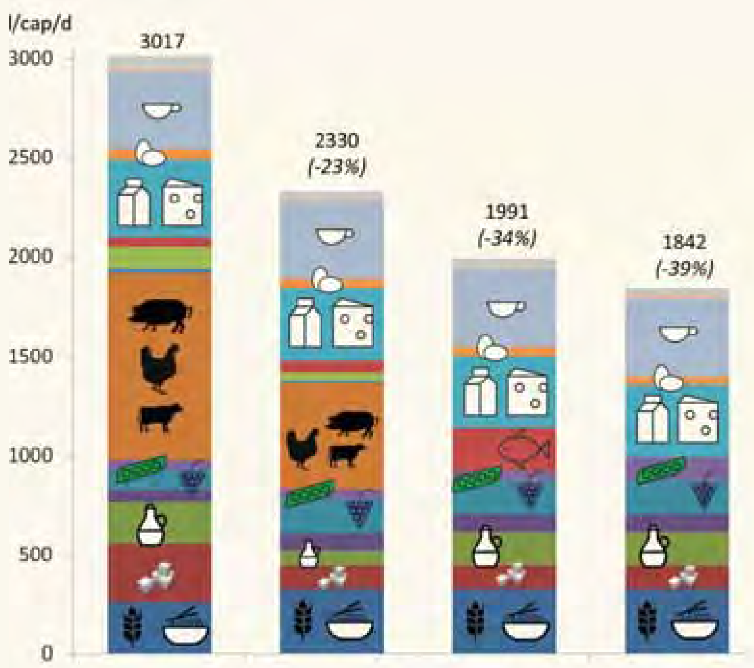


Within this table, lower numbers are better.

HAMBURG

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Hamburg. Four diet scenarios are shown. The current diet of the inhabitants of Hamburg leads to a WF of 3 017 l/cap/d, an amount that exceeds the direct water use of the city (51.8 m³/cap/year which equals 144 l/cap/d) substantially. A healthy diet, as recommended by national German dietary guidelines (lebensmittelbezogene Empfehlungen, Deutsche Gesellschaft für Ernährung), leads to a WF of 2330 l/cap/d, so a reduction of 23%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 34% reduction to 1 991 l/cap/d) and a vegetarian diet (a 39% reduction to 1 842 l/cap/d). Hamburg's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

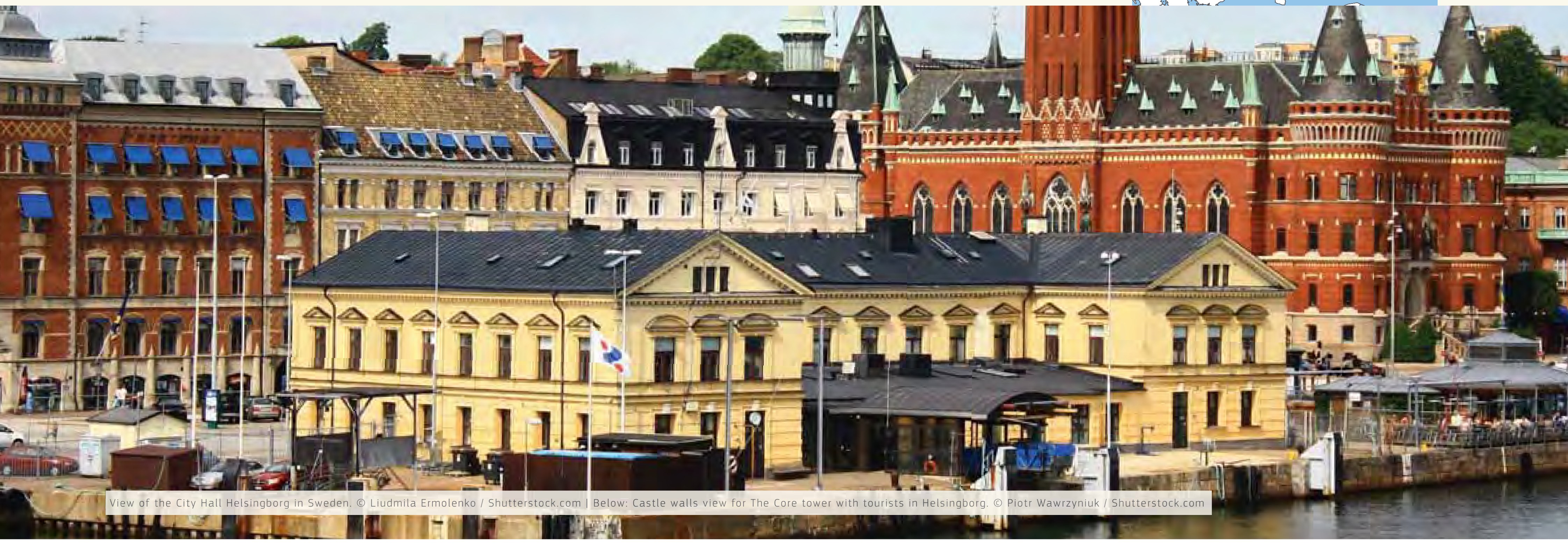
l/cap/d = litres / cap / day

Helsingborg

National Flag

Coat of Arms

56°02′48″ N | 12°41′39″ E   *Country: Sweden, Region: Scania*



View of the City Hall Helsingborg in Sweden. © Liudmila Ermolenko / Shutterstock.com | Below: Castle walls view for The Core tower with tourists in Helsingborg. © Piotr Wawrzyniuk / Shutterstock.com

HELSINGBORG

Helsingborg is a Swedish city of 130 000 in the fast-growing Öresund Region, a transnational metropolitan area that links Denmark and Sweden. The modern Helsingborg was established in 1970–71 from its amalgamation with the adjacent municipalities of Kattarp, Mörarp, Vallåkra and Ödåkra, making it the forth largest population area in Sweden. The city is a major regional centre of trade and business and a transport hub linking cars, buses, trains, ferries and aeroplanes. There are commuter trains and buses to several cities and towns, and it is close to Copenhagen International Airport. Helsingborg has a humid continental climate with warm summers and no dry season. Over the entire year, the most common forms of precipitation are moderate rain, light rain, and moderate snow.

Resident population (x 1 000)	133
Population density (inhabitants/km²)	392
Waste production kg/cap/year	460
% Recycling and composting	47
% Incineration with energy recovery	51
% Landfill	1

ENVIRONMENTAL QUALITY

Although its landscape is heavily shaped by human influence, the city of Helsingborg has a long-standing tradition of protecting its urban biodiversity, and aims to steadily increase its green and blue environmental areas. These efforts were rewarded in 2009 when it received the award for "Best Environmental Community" in Sweden. Energy used in Helsingborg is from sustainable and renewable resources. The municipal region is energy-neutral, in the sense that supplies of renewable energy from plants within the region correspond to the total volume of energy used, although with some exchange with other regions. Energy use is effective and efficient, encompasing strong collaboration on energy-related issues.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year	W.E.I. DEMAND	W.E.I. CONSUMPTION	Water DEPENDENCY
26.4%	25.5%	5.2%	0.0%

Evapotranspiration difference (**mm/y**)

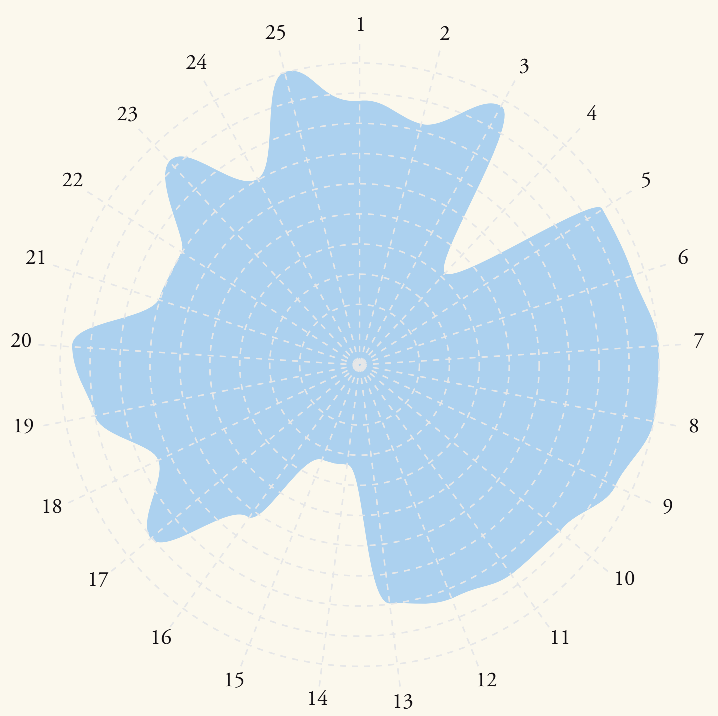
348.6

HELSINGBORG

CITY BLUEPRINT ©

Helsingborg is leading in almost all aspects of the urban watercycle. The city can improve in some areas, such as reduction of solid waste production.

The BCI (Blue City Index) **is 7.8**



The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is 7.8

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	8.7
2	Tertiary WWT	8.3
3	Groundwater Quality	9.8
4	Solid Waste Collected	4.1
5	Solid Waste Recycled	9.6
6	Solid Waste Energy Recovered	9.6
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	9.4
10	Nutrient Recovery	8.7
11	Energy Recovery	8.7
12	Sewage Sludge Recycling	8.3
13	WWT Energy Efficiency	8.0
14	Average Age Sewer	3.4
15	Operation Cost Recovery	3.3
16	Water System Leakages	6.2
17	Stormwater Separation	9.0
18	Green Space	7.5
19	Climate Adaptation	9.0
20	Drinking Water Consumption	9.7
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.0
23	Public Participation	9.2
24	Water Efficiency Measures	7.0
25	Attractiveness	10.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., Koop S.H.A., Sjerps R.M.A., 2016. City Blueprints: baseline assessments of water management and climate change in 45 cities. Environment, Development and Sustainability, 18, 1113–1128
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Panoramic image of the port in Helsingborg. © Antony McAulay / Shutterstock.com

WATER BASICS

Helsingborg is a mid-sized coastal city. The water temperature around Helsingborg is extremely variable throughout the year, ranging from an average of 2.3°C in February up to an average 18.4°C in August.
Three lakes around the Skåne Region are the main sources of water supply to the Helsingborg municipality: Lake Bolmen in Småland and the Bolmen Lake; Lake Ringsjön is used as reserve supply.

Annual average rainfall (mm)	700
Daily average air temperature (°C)	7.9
% of blue and green area	40.0
% of soil sealed	32.6
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	24.7

DRINKING WATER

All drinking water produced for Helsingborg is supplied by Sydvatten, a publicly owned company in the region of Skåne, one of Sweden's largest drinking water utilities. After adjusting the pH and alkaline levels, a small amount of disinfecting agent is added, before the drinking water is distributed to households and industry.

% of drinking water samples complying with drinking water regulation	94
% urban population with access to potable drinking water	100
% leakage rate water distribution system	19.0
Drinking water consumption (m^3/cap/year)	51.8
Drinking water consumption (litres/cap/day)	144

WASTEWATER

Öresundsverket is the largest wastewater treatment plant in Helsingborg, located between West Harbour and North Harbour. About 130 000 people and a variety of industries are serviced by the plant, which receives an average 50 000 m^3/day, and has a maximum capacity of 67 000 m^3/day. It is one of the largest to include a biological phosphorus removal system for the recovery of phosphate for fertiliser.

% population connected to at least secondary wastewater treatment	87.0
% population connected to tertiary wastewater treatment	83.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	100
Average age sewer (years)	43
% sewer with separated stormwater and sanitary water	90.0

Dunkers Art Museum and gallery, located on the waterfront in Helsingborg city center. © Sophie McAulay / Shutterstock.com

SWEDEN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	37%
2036-2065	25%
2066-2095	90%
0	600%

Average % change in population directly affected

2006-2035	31%
2036-2065	12%
2066-2095	68%
0	750%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SOUTH SWEDEN

AVERAGE ANNUAL FLOOD RISK

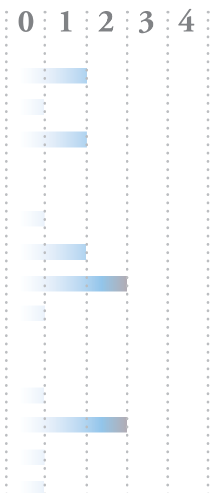
Flood direct economic damage: 12 M€
0 — 300M€

Population directly affected: 287 inh.
0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

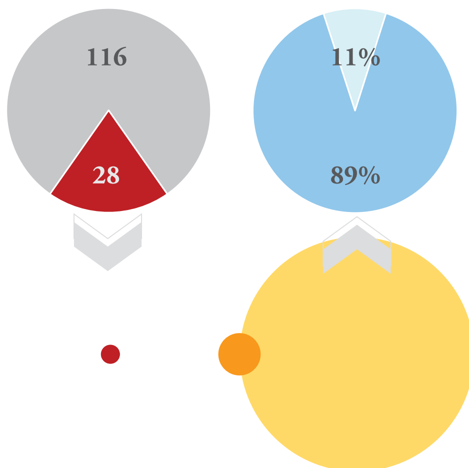
0.7



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



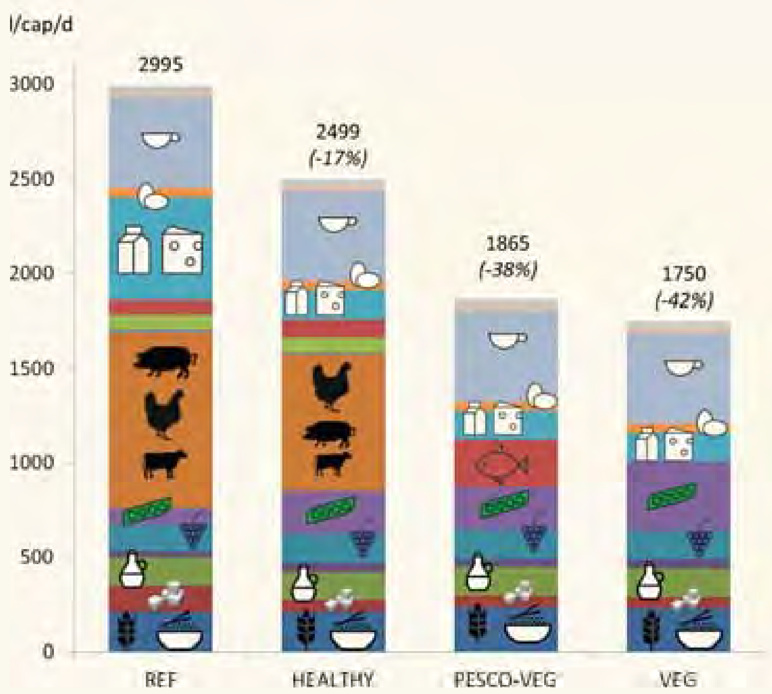
ALERT: 2 WARNING: 4 WATCH: 22

Stress incidents for drought level

HELSINGBORG

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Helsingborg. Four diet scenarios are shown. The current diet of the inhabitants of Helsingborg leads to a WF of 2 995 l/cap/d, an amount that exceeds the direct water use of the city (51.8 m^3/cap/year which equals 144 l/cap/d) substantially. A healthy diet, as recommended by the Swedish National Food Agency (Livsmedelsverket), leads to a WF of 2 499 l/cap/d, so a reduction of 17%. Even greater reductions in the WF are observed for a pesco vegetarian diet (a 38% reduction to 1865 l/cap/d) and a vegetarian diet (a 42% reduction to 1 750 l/cap/d). Helsingborg citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

Helsinki

60°10′10″ N | 24°56′07″ E *Country: Finland, Region: Helsinki*


National Flag


City Flag


Coat of Arms

Panorama Of Embankment In Helsinki. © Grisha Bruev / Shutterstock.com | Below: Suomenlinna Maritime fortress on the Islands in the harbour of Helsinki, Finland. © Anton Kudelin / Shutterstock.com

HELSINKI

Helsinki is Finland's modern and cosmopolitan capital, and the EU's most northerly. It is on the tip of a peninsula in the Baltic Sea, and includes 315 islands. The city's population is around 630 000, but over 1.12 million for the wider urban area, representing the world's most northerly with over 1 million people. Helskinki is Finland's main political, financial, and cultural centre, generating a third of its GDP, and with around 75% of international companies based in the region.

Helsinki's climate, typical of its northerly situation, combines characteristics of both a maritime and a continental climate. The proximity of the Arctic Ocean and the North Atlantic creates cold weather, while the Gulf Stream brings in warmer air.

Resident population (x 1 000)	613
Population density (inhabitants/km^2)	856
Waste production kg/cap/year	310[1]
% Recycling and composting	45
% Incineration with energy recovery	47
% Landfill	8

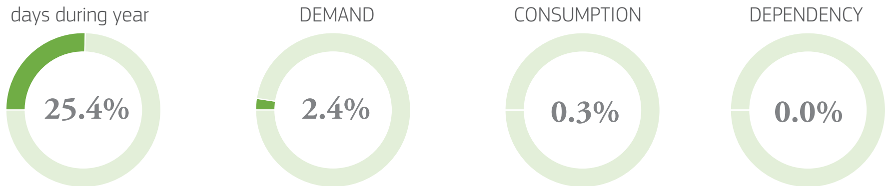
ENVIRONMENTAL QUALITY

Over recent years, the city has produced several environmental programmes that contributes to its overall environmental management. These include programmes on climate action, noise reduction, biodiversity and energy efficiency, the last of which has achieved 90%, also reducing emissions. Urban planning applies an eco-efficiency approach to promoting a denser urban structure and improved public transport system.

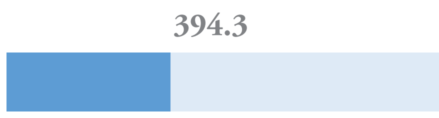
Helsinki is one of the cleanest metropolitan areas in Europe in terms of air quality, which is frequently measured as being predominantly good or satisfactory. In addition, environmental education services are targeted at all age groups.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



Evapotranspiration difference (**mm/y**)



HELSINKI

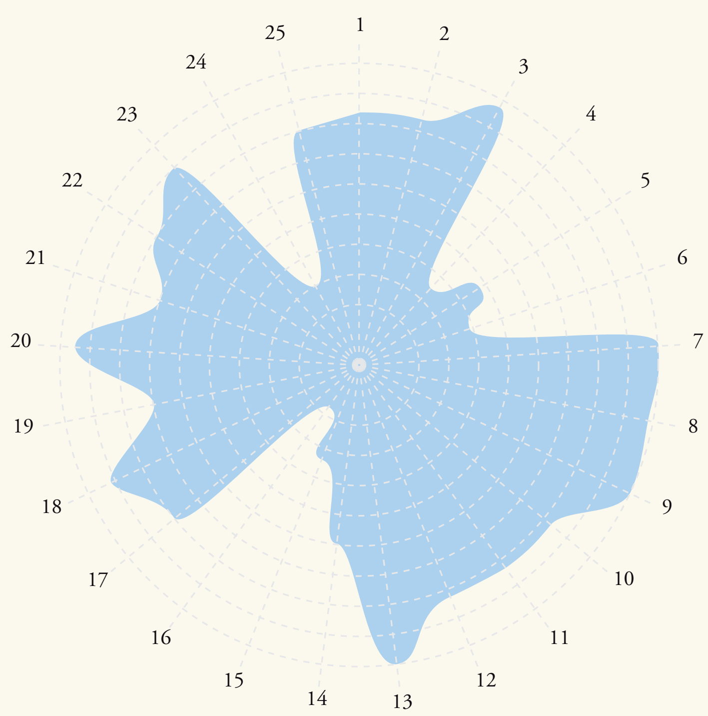
CITY BLUEPRINT ©

Helsinki performs well in waste water treatment, climate adaptation plans and low drinking water consumption but can reduce its infrastructure leakages and improve its solid waste treatment considerably.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **6.8**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	8.3
2	Tertiary WWT	8.3
3	Groundwater Quality	9.8
4	Solid Waste Collected	3.4
5	Solid Waste Recycled	4.7
6	Solid Waste Energy Recovered	3.8
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	8.3
11	Energy Recovery	8.3
12	Sewage Sludge Recycling	8.3
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	6.0
15	Operation Cost Recovery	3.3
16	Water System Leakages	1.8
17	Stormwater Separation	8.0
18	Green Space	9.3
19	Climate Adaptation	7.0
20	Drinking Water Consumption	9.4
21	Climate Robust Buildings	7.0
22	Management and Action Plans	8.0
23	Public Participation	9.0
24	Water Efficiency Measures	3.0
25	Attractiveness	8.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
[1] http://www.pksjatevirrat.fi/?mo=wastestats
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Aerial panorama of the Old Town architecture. © Scanrail1 / Shutterstock.com

WATER BASICS

The main water bodies in Helsinki are the Gulf of Finland and Vantaa River, which runs through Helsinki and into the sea. However, water supply originates from Lake Päijänne, 120 km to the north, carried via a rock tunnel. The 70 million m³/year of water drawn from the lake is only 1% of its natural discharge, and so has no impact. Lake Hiidenvesi, 50 km north west of Helsinki, serves as a backup.

Annual average rainfall (mm)	630
Daily average air temperature (°C)	5.0
% of blue and green area	45.7
% of soil sealed	48.7
% flooded by 1-m sea-level rise	3.2
% flooded by 1-m river-level rise	28.8

DRINKING WATER

The water distribution network includes approximately 1 100 km of pipeline and six water reservoirs with a total volume of 101 000 m³, representing about 70% of daily water consumption. The reservoirs help maintain stable pressure, store water for emergencies, and provide a buffer to smooth out consumption peaks. Drinking water quality is high, for which monitoring data are freely available.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	41.0
Drinking water consumption (m³/cap/year)	58.4
Drinking water consumption (litres/cap/day)	162

WASTEWATER

The Helsinki region produces around a 100 million m³ of wastewater annually. The wastewater is treated at two centralised treatment plants in Viikinmäki, Helsinki (serving the city proper), and in Suomenoja, Espoo (included in the Helsinki region). In order to protect the shallow coast of the Baltic Sea and to preserve its recreational value, the treated wastewater is conducted into the open sea in front of Helsinki and Espoo

% population connected to at least secondary wastewater treatment	99.0[2]
% population connected to tertiary wastewater treatment	99.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	100
Average age sewer (years)	40
% sewer with separated stormwater and sanitary water	95

Helsinki city center and old port.
© canadastock / Shutterstock.com

FINLAND

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 17%

2036-2065 -7%

2066-2095 -15%

-30 0 400%

Average % change in population directly affected

2006-2035 7%

2036-2065 -10%

2066-2095 -8%

-30 0 550%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SOUTH FINLAND

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 13 M€

0 300M€

Population directly affected: 418 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

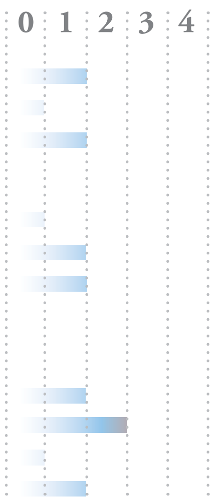
TRENDS & PRESSURES

0.8

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

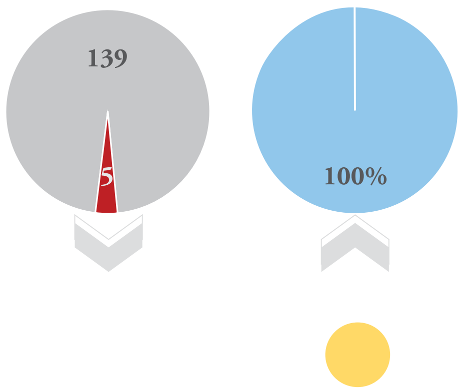
Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate



Within this table, lower numbers are better.

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



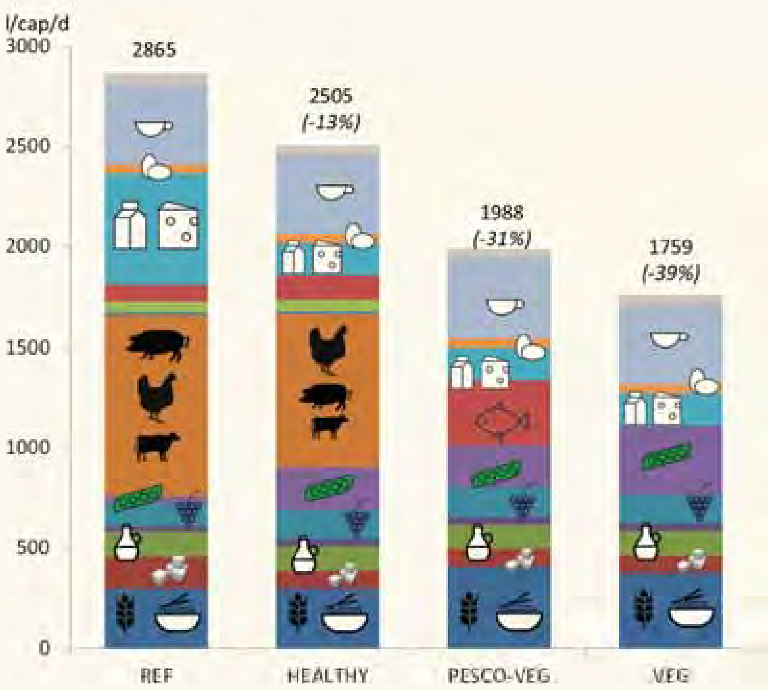
ALERT: 0 WARNING: 0 WATCH: 5

Stress incidents for drought level

HELSINKI

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Helsinki. Four diet scenarios are shown. The current diet of the inhabitants of Helsinki leads to a WF of 2 865 l/cap/d, an amount that exceeds the direct water use of the city (58.4 m³/cap/year which equals 162 l/cap/d) substantially. A healthy diet, including meat as recommended by the Finnish National Nutrition Council (Valtion ravitsemusneuvottelukunta), leads to a WF of 2 505 l/cap/d, so a reduction of 13%. Even greater reductions in the WF are observed for a healthy pesco-vegetarian diet (a 31% reduction to 1 988 l/cap/d) and a vegetarian diet (a 39% reduction to 1 759 l/cap/d). Helsinki citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
[2] M Copeland, Helsinki Region Environmental Services Authority HSY. Written communication 21.4.2016
Vanham D, Gawlik BM, Bidoglio G (2017) Food consumption and related water resources in Nordic cities. Ecological Indicators, 74: 119–129.

Istanbul

41°00′49″ N | 28°56′58″ E *Country: Turkey, Region: Marmara*


National Flag


Coat of Arms


Golden Horn, Istanbul, Turkey. © Boris Stroujko / Shutterstock.com

Below: Grand Bazaar in Istanbul with unidentified people. It is one of the largest and oldest covered markets in the world, with 61 covered streets and over 3,000 shops. © Christian Mueller / Shutterstock.com

ISTANBUL

Istanbul is the largest urban agglomeration of Europe, with a population of 14.3 million. Located in north-west Turkey, it lies in both Europe, west of the Boshphorous strait (connecting the Black Sea to the Sea of Marmara), and in Asia to the east. Istanbul has faced water scarcity throughout its history due to its distance from reliable water sources and its population growth, now with one of the fastest growth rates in Europe at 2.8%. Temperature, precipitation, and other data show that Istanbul has become warmer and drier over the past five decades. Istanbul lies in a transitional climatic zone which has a borderline Mediterranean climate, humid subtropical climate and oceanic climate.

ENVIRONMENTAL QUALITY

In recent years, Istanbul has suffered from drought, especially in the period 2006-08, which experienced the lowest recorded rainfall in 50 years. The frequency of extreme weather events, such as floods and droughts, is projected to increase as a consequence of climate change in the Mediterranean region.
Istanbul is already addressing this challenge by implementing effective strategies and developing adaptation plans, including water saving campaigns, the transfer of water from adjacent basins, and the reuse of treated wastewater.
As in many mega cities, air pollution is of great concern and an important component of the city's environmental agenda.

Resident population (x 1 000)	14 026
Population density (inhabitants/km²)	2 625
Waste production kg/cap/year	419
% Recycling and composting	1
% Incineration with energy recovery	0
% Landfill	99

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year	W.E.I. DEMAND	W.E.I. CONSUMPTION	Water DEPENDENCY
46.9%	126%	25.0%	0.0%

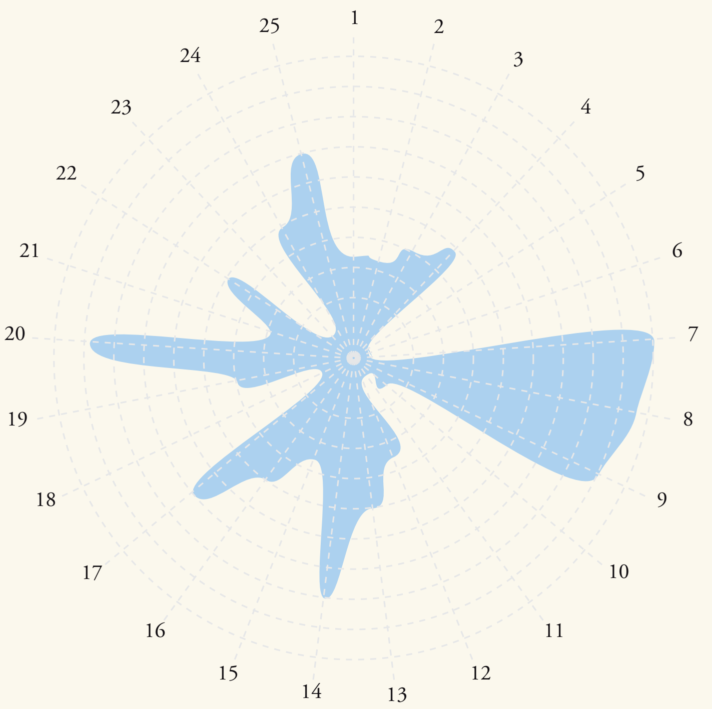
Evapotranspiration difference (**mm/y**)

ISTANBUL

CITY BLUEPRINT ©

Istanbul is Europe's only megacity, and therefore faces major water challenges. The city, performs well in terms of water use and drinking water consumption is low. Wastewater treatment, solid-waste treatment and climate adaptation need improvement.

The BCI (Blue City Index) **is 3.5**



The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **3.5**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	3.5
2	Tertiary WWT	3.4
3	Groundwater Quality	4.0
4	Solid Waste Collected	4.9
5	Solid Waste Recycled	0.1
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.5
9	Drinking Water Quality	9.0
10	Nutrient Recovery	1.2
11	Energy Recovery	0.2
12	Sewage Sludge Recycling	3.5
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	8.0
15	Operation Cost Recovery	3.6
16	Water System Leakages	5.0
17	Stormwater Separation	7.0
18	Green Space	1.3
19	Climate Adaptation	4.0
20	Drinking Water Consumption	8.9
21	Climate Robust Buildings	3.0
22	Management and Action Plans	5.0
23	Public Participation	0.5
24	Water Efficiency Measures	5.0
25	Attractiveness	7.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen K., Sjerps R.M.A., 2016. Istanbul: the challenges of integrated water resources management in Europa's megacity. Environment, Development and Sustainability, 18, 1-17
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Collection of turkish ceramics on sale at the Grand Bazaar in Istanbul, Turkey. © Yulia Grigoryeva / Shutterstock.com

WATER BASICS

With little groundwater, Istanbul has long been dependent on bringing supplies from distant surface water sources, mostly from Asia. The Romans built the first aqueducts, while the Ottomans extended the infrastructure with extensive storage cisterns. The system continues to be expanded in modern times to meet the demands of rapid population growth with new reservoirs and delivery systems.

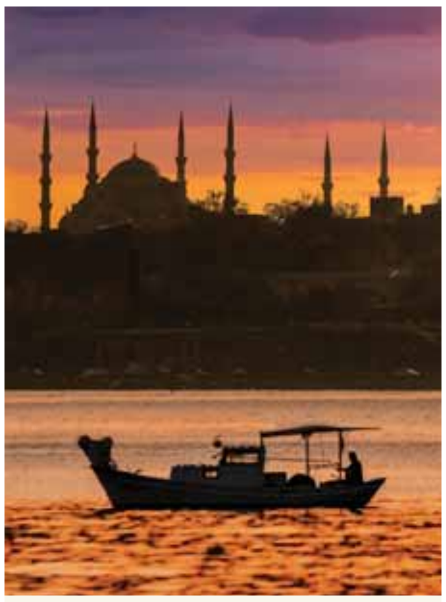
Annual average rainfall (mm)	640
Daily average air temperature (°C)	14.0
% of blue and green area	20.0
% of soil sealed	72.2
% flooded by 1-m sea-level rise	‹ 40%
% flooded by 1-m river-level rise	‹ 40%

Aerial view of Istanbul. © Koraysa / Shutterstock.com

DRINKING WATER

Nearly all of Istanbul's drinking water (97%) comes via surface water storage reservoirs, the most important being the Omerli-Darlik system in Asia and the Terkos-Alibeykoy system in Europe. Both systems consist of dams, reservoirs, water treatment plants and pipelines. Some reservoirs located within the metropolitan area are vulnerable to pollution from unofficial settlements lacking adequate sanitation, and therefore require vigilence.

% of drinking water samples complying with drinking water regulation	90.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	25.0
Drinking water consumption (m^3/cap/year)	69.5
Drinking water consumption (litres/cap/day)	193



Istanbul silhouette and fishing boat.
© nexus 7 / Shutterstock.com

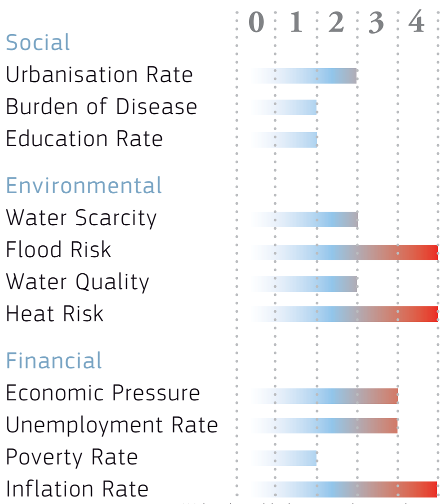
WASTEWATER

Istanbul's 9 600-km wastewater network includes five biological waste-water treatment plants. Treated wastewaters are discharged into the Bosphorus, into a lower layer of water which flows northwards towards the Black Sea.The sewer system consists of mostly separate sanitary and stormwater drains. However, illegal cross-connections mean untreated wastewater can reach stormwater drains that flow into and threaten drinking water reservoirs.

% population connected to at least secondary wastewater treatment	35.0
% population connected to tertiary wastewater treatment	34.0
% wastewater that is treated with nutrient-recovering techniques	33.8
% wastewater that is treated with energy-recovering techniques	6.0
Average age of sewer (years)	20
% sewer with separated stormwater and sanitary water	70.0

TRENDS & PRESSURES

2.4

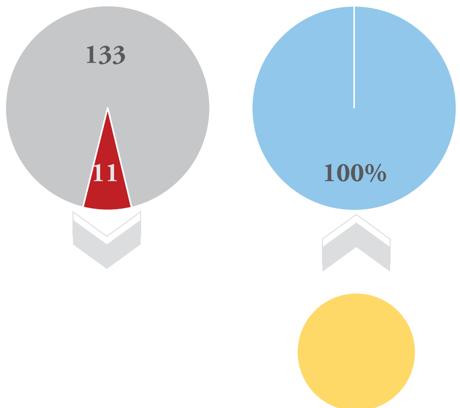


Within this table, lower numbers are better.

Suleymaniye mosque.
© Sabino Parente / Shutterstock.com

DROUGHT STATUS: 2012 - 2015

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



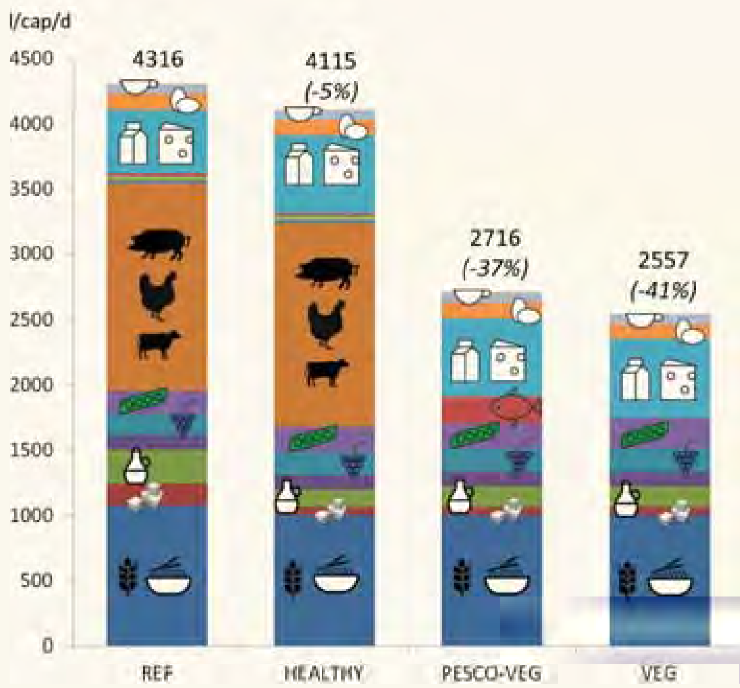
ALERT: 0 WARNING: 0 WATCH: 11

Stress incidents for drought level

ISTANBUL

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Istanbul. Four diet scenarios are shown. The current diet of the inhabitants of Istanbul leads to a WF of 4 316 l/cap/d, an amount that exceeds the direct water use of the city (69.5 m^3/cap/year which equals 193 l/cap/d) substantially. A healthy diet, as recommended by dietary guidelines for Turkey, leads to a WF of 4 115 l/cap/d, so a reduction of 5%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 37% reduction to 2 716 l/cap/d) and a vegetarian diet (a 41% reduction to 2 552 l/cap/d). Istanbul's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:

Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

Jerusalem

31°46′08″ N | 35°12′58″ E *Country: Israel, Region: Jerusalem District*


National Flag


City Flag

Coat of Arms


View of the Temple Mount, Dome of the Rock and Al Aqsa Mosque from the Mount of Olives in Jerusalem, Israel. © alefbet / Shutterstock.com | Below: Long narrow street in the Old City of Jerusalem © badahos / Shutterstock.com

JERUSALEM

Jerusalem is one of the world's oldest cities and holy centre to three Abrahamic religions. Israel's primary governmental institutions are located in the city, which lies between the Mediterranean and the Dead Sea on a plateau in the Judean Mountains, and surrounded by valleys and dry riverbeds.
In the past, Jerusalem's economy relied almost exclusively on religious pilgrims. Tourism and religious visitors remain a major source of income today. With the foundation of the State of Israel, the national government became a major force in the local economy generating many jobs, and stimulating new economic and entrepreneurial activities.
Jerusalem's Mediterranean climate is characterised by hot dry summers, and mild, wet winters, but with rare snowfall.

Resident population (x 1 000)	850
Population density (inhabitants/km²)	6 790
Waste production kg/cap/year	610
% Recycling and composting	14
% Incineration with energy recovery	0
% Landfill	86

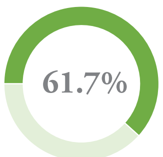
ENVIRONMENTAL QUALITY

Jerusalem's many challenges include severe traffic congestion and poor environmental infrastructure.
In response, the municipality has established an environmental policy that aims to improve the situation. While struggling with air pollution, the population is generally satisfied with the city's cleanliness and amount of green space. A reliable and sufficient water supply remains a critical challenge.
The city's solid waste output is estimated to increase by 2% per year, to reach 1.55 kg/pers by 2019. With a projected population of about 940 000, the total will reach over 500 000 tonnes. Options to generate energy from at least part of this waste are being explored.

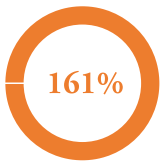
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

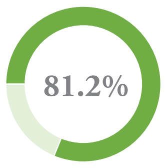
% SOIL WATER STRESS days during year



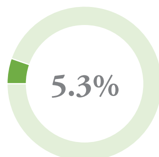
W.E.I. DEMAND



W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)

JERUSALEM

CITY BLUEPRINT ©

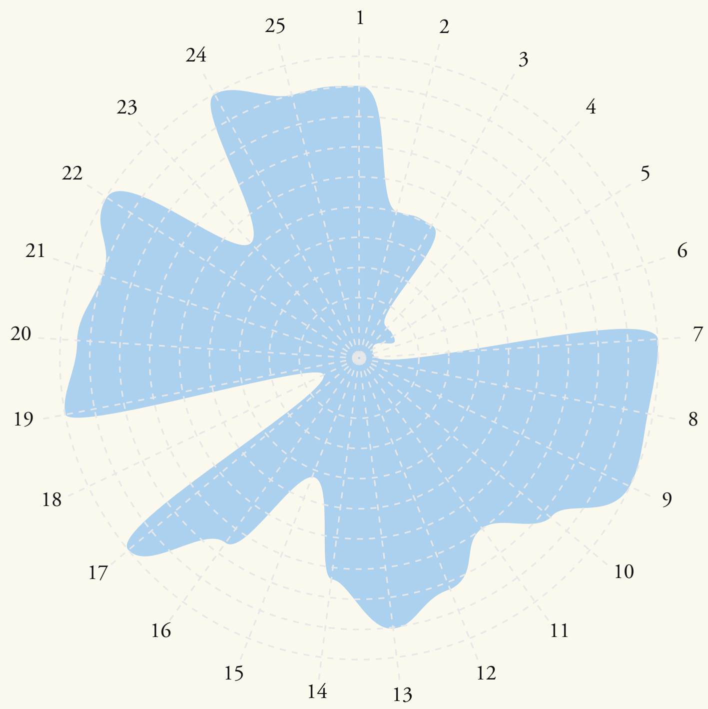
Jerusalem is leading in water conservation and has well-developed climate adaptation plans. The city can improve its solid-waste management and increase its blue-green area to further reduce its climate vulnerability.

The BCI (Blue City Index) **is 6.0**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **6.0**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.0
2	Tertiary WWT	5.0
3	Groundwater Quality	5.0
4	Solid Waste Collected	1.4
5	Solid Waste Recycled	1.4
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	8.2
11	Energy Recovery	7.0
12	Sewage Sludge Recycling	8.2
13	WWT Energy Efficiency	9.0
14	Average Age Sewer	7.4
15	Operation Cost Recovery	4.1
16	Water System Leakages	7.5
17	Stormwater Separation	10.0
18	Green Space	1.3
19	Climate Adaptation	10.0
20	Drinking Water Consumption	9.4
21	Climate Robust Buildings	9.0
22	Management and Action Plans	10.0
23	Public Participation	5.2
24	Water Efficiency Measures	10.0
25	Attractiveness	9.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Various colored spices on the Mahane Yehuda Market in Jerusalem. © seregalsv / Shutterstock.com

WATER BASICS

For thousands of years, the Gihon spring and the associated Siloam reservoir in the Kidron Valley remained Jerusalem´s main water source, later also depending on other natural springs in the surrounding area. With average rainfall of 590 mm, falling mainly from November to March, water supply is also dependent on unconventional sources of desalinised seawater and purified wastewater, via aquifer recharge.

Annual average rainfall (mm)	554
Daily average air temperature (°C)	15.0
% of blue and green area	20.0
% of soil sealed	72.2
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	39.4

The view on the high ramparts and walled Golden Gate with the Muslim Cemetery in front of it from the Kidron Valley. © eFesenko / Shutterstock.com

DRINKING WATER

Drinking water is supplied by the municipal water-wastewater utility, Hagihon, serving a million people in the city and surrounding area. Drinking water quality, as for the rest of Israel, meets international standards. Bacteriological quality is ensured by chlorine disinfection. Hagihon applies comprehensive maintenance, replacement and quality-testing programmes to meet the growing needs of the population.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	12.5
Drinking water consumption (m^3/cap/year)	57.7
Drinking water consumption (litres/cap/day)	160

Pilgrims lit candles at the Church of the Holy Sepulchre © Anton Kudelin / Shutterstock.com

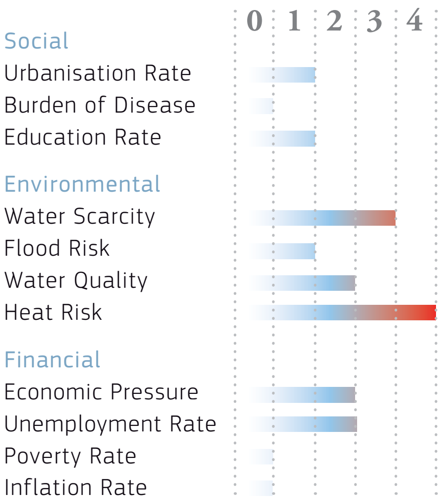
WASTEWATER

Hagihon also manages wastewater services through its subsidiary MATVI, which is responsible for wastewater treat-ment at three plants. The largest, Sorek, treats 80 000 m^3/day of wastewater (50% of the total). Storm drainage maximises recharge of rainfall to groundwater through 'water conservation construction'. Development projects are ongoing to keep up with the growing population.

% population connected to at least secondary wastewater treatment	90.2
% population connected to tertiary wastewater treatment	50.2
% wastewater that is treated with nutrient-recovering techniques	91.0
% wastewater that is treated with energy-recovering techniques	77.9
Average age of sewer (years)	23
% sewer with separated stormwater and sanitary water	100

TRENDS & PRESSURES

1.6



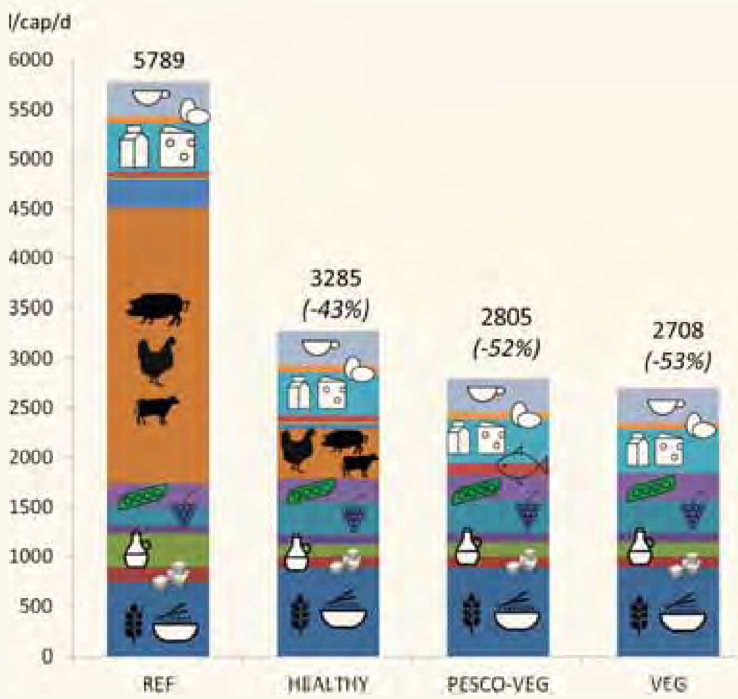
Within this table, lower numbers are better.

Dome of the Rock on the Temple Mount in the Old City of Jerusalem Israel. © Beata Bar / Shutterstock.com

JERUSALEM

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Jerusalem. Four diet scenarios are shown. The current diet of the inhabitants of Jerusalem leads to a WF of 5 789 l/cap/d, an amount that exceeds the direct water use of the city (57.7 m^3/cap/year which equals 160 l/cap/d) substantially. A healthy Mediterranean diet, leads to a WF of 3 285 l/cap/d, so a reduction of 43%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 52% reduction to 2 805 l/cap/d) and a vegetarian diet (a 53% reduction to 2 708 l/cap/d). Jerusalem's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

Kristianstad

56°01′52″ N | 14°09′08″ E *Country: Sweden, Region: Skane*


National Flag


Coat of Arms


Kristianstad, picturesque city in the south of Sweden. © Fotos593 / Shutterstock.com | Below: Old historic cannons in Kristianstad. © Fotos593 / Shutterstock.com

KRISTIANSTAD

Kristianstad is a city of 37 000 inhabitants, with about 80 000 in the wider municipality. It is in the Skåne province in southern Sweden, about 100 km north-east of Malmö. It was founded in 1614, then within Denmark, by the Danish King Christian IV, but was transferred to Sweden in 1658 under the Treaty of Roskilde. Due to its strategic position between Sweden and Denmark, it was a garrison town for most of its history. In recent decades, it has transformed into a commercial city, and is now the largest centre of food production in Sweden, benefiting economically from its location in the Øresund Region and close to Malmö and Copenhagen. Geographically, the city is located in a low-lying area, with surrounding land drained for agriculture, with the result that the city is vulnerable to flooding.

Resident population (x 1 000)	82
Population density (inhabitants/km²)	66
Waste production kg/cap/year	460
% Recycling and composting	47
% Incineration with energy recovery	51
% Landfill	1

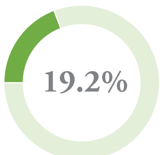
ENVIRONMENTAL QUALITY

The Municipality of Kristianstad works actively on environmental issues, with the stated aim of creating a great living environment for everyone. The municipality includes many different natural environments and many rare species. Moreover, beneath Kristianstad Plain is a huge natural reservoir (aquifer) of good quality groundwater. The municipality has adopted fifteen local environmental objectives. This includes an ambition to become fossil-fuel free by promoting energy efficiency, and transfer to biogas and biofuels for heating, energy and transport. For water, the objectives are to improve and protect surface water bodies and groundwater.

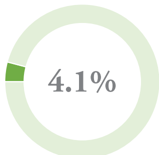
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

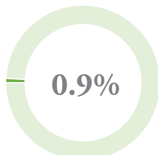
% SOIL WATER STRESS days during year



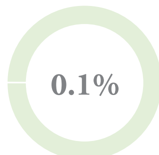
W.E.I. DEMAND



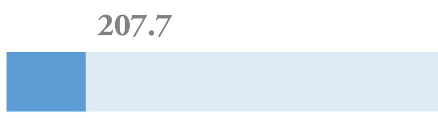
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



KRISTIANSTAD

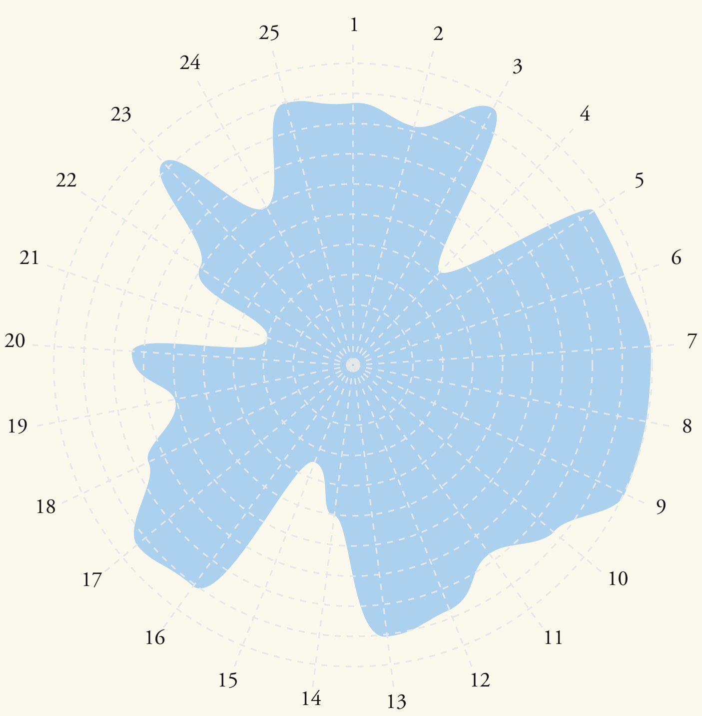
CITY BLUEPRINT ©

Kristianstad performs very well for almost all water management indicators. The city can still improve with respect to climate adaptation policy and in reducing solid-waste production.

The BCI (Blue City Index) **is 7.5**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).
The Blue City Index is **7.5**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	8.7
2	Tertiary WWT	8.3
3	Groundwater Quality	9.8
4	Solid Waste Collected	4.1
5	Solid Waste Recycled	9.6
6	Solid Waste Energy Recovered	9.6
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	8.7
11	Energy Recovery	7.8
12	Sewage Sludge Recycling	8.7
13	WWT Energy Efficiency	9.0
14	Average Age Sewer	5.0
15	Operation Cost Recovery	3.3
16	Water System Leakages	9.0
17	Stormwater Separation	9.3
18	Green Space	7.5
19	Climate Adaptation	6.0
20	Drinking Water Consumption	7.3
21	Climate Robust Buildings	3.0
22	Management and Action Plans	6.0
23	Public Participation	9.2
24	Water Efficiency Measures	6.0
25	Attractiveness	9.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Natural forest landscape in Kristianstad. © Fotos593 / Shutterstock.com

WATER BASICS

Kristianstad was built on marshy land which, from the 1860s, was drained for farmland. Part of the town, including the water treatment works, is now 2.5 metres below sea level, the lowest point in Sweden. The River Helge flows through the wetlands, with seasonal flooding that brings the wetlands into the heart of the town, and forming part of the UNESCO-recognised Kristianstad Vattenrike Biosphere Reserve.

Annual average rainfall (mm)	540
Daily average air temperature (°C)	7.0
% of blue and green area	40.0
% of soil sealed	36.0
% flooded by 1-m sea-level rise	0.8
% flooded by 1-m river-level rise	19.3

DRINKING WATER

Kristianstad has an abundant water supply, mainly from the groundwater of the the Kristianstad Plain aquifer, one of the largest in northern Europe. Abstraction is from wells close to the city centre. The same aquifer supplies other nearby towns, private industry supplies, and some agricultural irrigation. Protection areas are in place to protect the groundwater from surface pollution, including from agriculture.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	5.0
Drinking water consumption (m^3/cap/year)	104.8
Drinking water consumption (litres/cap/day)	291

WASTEWATER

Kristianstad has a conventional municipal wastewater collection and treatment system. In line with ambitions to be 100% fossil-fuel free for energy, biogas from wastewater treatment is used partly for internal heating production (4 000 MWh) and partly as vehicle fuel (3 000 MWh). Around 50% is used for public busses, and the rest marketed for use in adapted commercial vehicles and private cars.

% population connected to at least secondary wastewater treatment	87.0
% population connected to tertiary wastewater treatment	83.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	90.0
Average age of sewer (years)	35
% sewer with separated stormwater and sanitary water	93.0

Pipe organ of the Church of Holy Trinity.
© Mikhail Markovskiy / Shutterstock.com

SWEDEN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 37%

2036-2065 25%

2066-2095 90%

0 600%

Average % change in population directly affected

2006-2035 31%

2036-2065 12%

2066-2095 68%

0 750%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SOUTH SWEDEN

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 12 M€

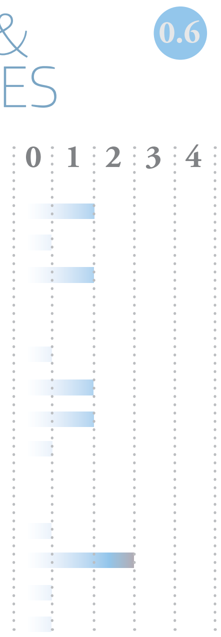
0 300M€

Population directly affected: 287 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

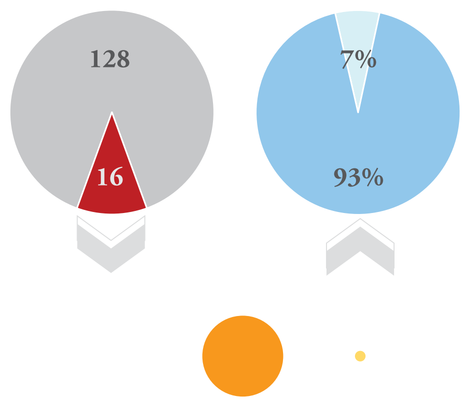
TRENDS & PRESSURES



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



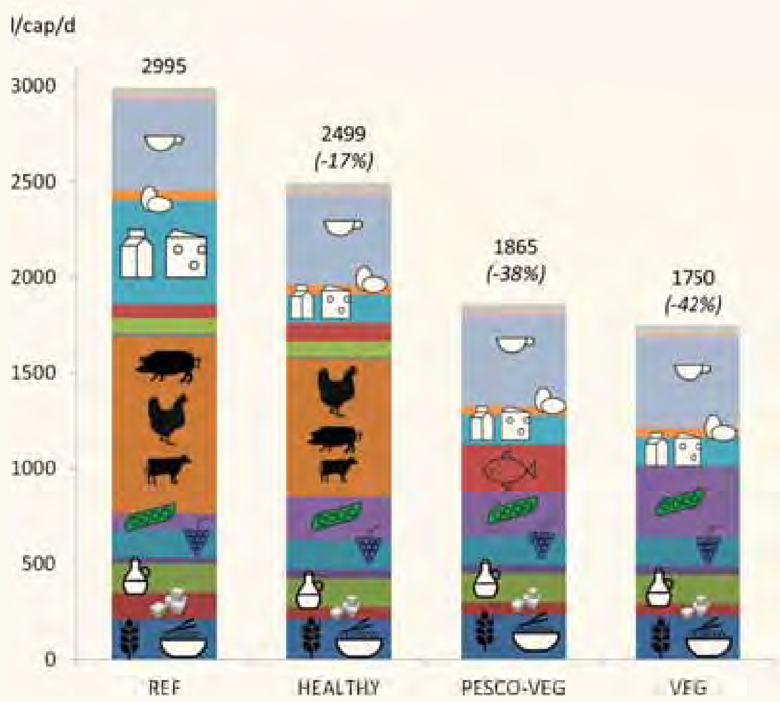
ALERT: 0 WARNING: 15 WATCH: 1

Stress incidents for drought level

KRISTIANSTAD

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



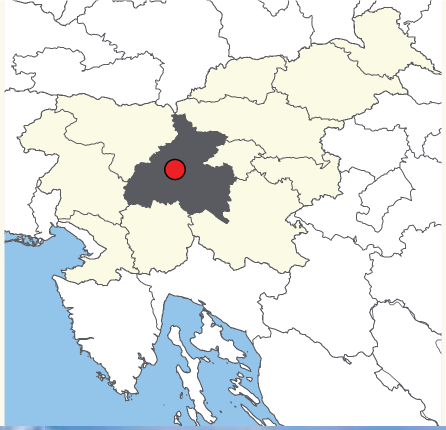
This figure shows the water footprint (WF) related to food consumption for Kristianstad. Four diet scenarios are shown. The current diet of the inhabitants of Kristianstad leads to a WF of 2 995 l/cap/d, an amount that exceeds the direct water use of the city (104.8 m^3/cap/year which equals 291 l/cap/d) substantially. A healthy diet, as recommended by the Swedish National Food Agency (Livsmedelsverket), leads to a WF of 2 499 l/cap/d, so a reduction of 17%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 38% reduction to 1865 l/cap/d) and a vegetarian diet (a 42% reduction to 1 750 l/cap/d). Kristianstad's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

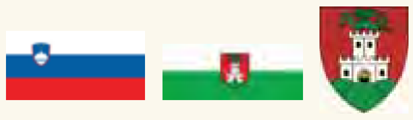
References:
Vanham D, Gawlik BM, Bidoglio G (2017) Food consumption and related water resources in Nordic cities. Ecological Indicators, 74: 119–129.

Ljubljana

46°03′03″ N | 14°30′18″ E   *Country: Slovenia, Region: Central Slovenia*



National Flag   City Flag   Coat of Arms



Panorama of the Slovenian capital Ljubljana. © Matej Kastelic / Shutterstock.com | Below: Cityscape of the Slovenian capital Ljubljana. © Matej Kastelic / Shutterstock.com

LJUBLJANA

Ljubljana is the capital and largest city of Slovenia. It is one of Europe's greenest and most liveable capitals, as recognised by its EU Commission award as Green Capital of Europe 2016. Ljubljana had made the largest number of changes towards environmentally friendly and sustainable development in the shortest period of time, starting from 2007 when its Vision 2025 sustainability strategy was adopted. It is situated in the Ljubljana Basin in Central Slovenia, between the Alps to the north and the Karst region to the south-west. The city's main watercourses are the Ljubljanica, the Sava, the Gradaščica, the Mali Graben, the Iška and the Iščica Rivers. The citiy's climate is oceanic.
Industry remains the most important employer, notably in the pharmaceutical, petrochemical and food processing sectors.

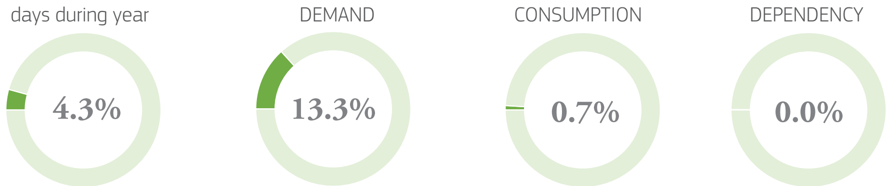
Resident population (x 1 000)	286
Population density (inhabitants/km^2)	1 040
Waste production kg/cap/year	410
% Recycling and composting	40
% Incineration with energy recovery	2
% Landfill	58

ENVIRONMENTAL QUALITY

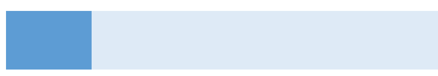
Ljubljana has recorded the highest share of separately collected waste of all European capitals, with 63% recycled in 2014. It is also the first European capital to embark on a path towards a Zero-Waste society.
The city's traffic policy encourages sustainable mobility solutions. In 2012, the core city centre area was closed to motorised vehicles. Urban cycling is rapidly increasing in popularity, and the free Bicike(LJ) bike-sharing network is proving a great success.
More and more public city buses in Ljubljana are fuelled by methane to reduce CO_2 emissions. Electric-powered vehicles called Kavalir can be hailed for a free ride within the core city centre area.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



Evapotranspiration difference (**mm/y**)



LJUBLJANA

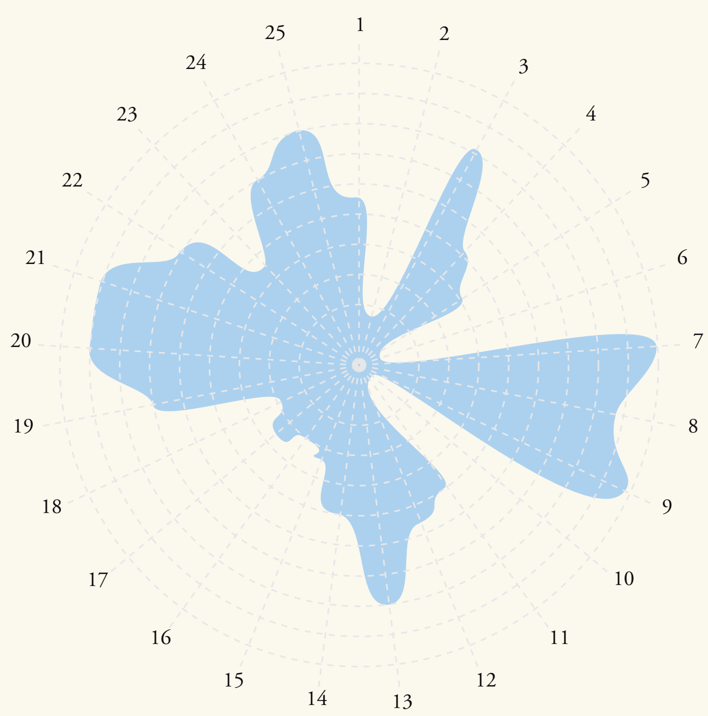
CITY BLUEPRINT ©

Ljubljana has a low level of drinking water consumption, a developed climate adaptation policy and energy-efficient wastewater treatment. However, nutrient recovery from wastewater is limited, and water leakages are still high.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **4.9**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	5.6
2	Tertiary WWT	1.9
3	Groundwater Quality	8.1
4	Solid Waste Collected	5.1
5	Solid Waste Recycled	4.1
6	Solid Waste Energy Recovered	0.3
7	Access to Drinking Water	10.0
8	Access to Sanitation	8.8
9	Drinking Water Quality	9.9
10	Nutrient Recovery	0.2
11	Energy Recovery	5.0
12	Sewage Sludge Recycling	5.6
13	WWT Energy Efficiency	8.0
14	Average Age Sewer	5.0
15	Operation Cost Recovery	3.3
16	Water System Leakages	3.0
17	Stormwater Separation	3.5
18	Green Space	2.9
19	Climate Adaptation	7.0
20	Drinking Water Consumption	9.0
21	Climate Robust Buildings	9.0
22	Management and Action Plans	7.0
23	Public Participation	4.6
24	Water Efficiency Measures	7.0
25	Attractiveness	8.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Interior of the Ljubljana Cathedral. © akturer / Shutterstock.com

WATER BASICS

Ljubljana is situated on its own ground-water sources. The water supply system distributes untreated natural water, which is possible due to the city's sensitive development, sustainable management and protection of its water sources.
The water resource lies beneath agricultural (43%) and urban (41%) areas. Both land uses are subjected to careful management and monitoring to protect groundwater quality.

Annual average rainfall (mm)	620
Daily average air temperature (°C)	8.0
% of blue and green area	25.1
% of soil sealed	47.5
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	23.0

DRINKING WATER

The main source of drinking water for Ljubljana's central water supply system is the Ljubljansko Polje aquifer, which is part of the Sava Basin and Ljubljana Marshes water body, and lies within the Danube River basin. Drinking water in Ljubljana is potable without any prior technological treatment. Drinking water is provided for free from a large number of public drinking fountains across the city during warmer parts of the year.

% of drinking water samples complying with drinking water regulation	99.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	35.0
Drinking water consumption (m^3/cap/year)	67.3
Drinking water consumption (litres/cap/day)	187

WASTEWATER

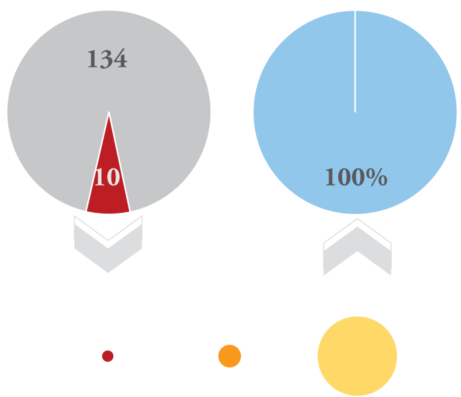
Urban wastewater is treated and discharged via the Ljubljana Central Wastewater Treatment Plant, with a capacity of 360 000 population equivalent and three small local systems. Three suburban municipalities are also connected to the central system. The network totals 730 km, of which around 65% is combined. The city's outskirts has mostly separated systems, including about 300 km of pipes for storm runoff.

% population connected to at least secondary wastewater treatment	56.0
% population connected to tertiary wastewater treatment	19.0
% wastewater that is treated with nutrient-recovering techniques	3.0
% wastewater that is treated with energy-recovering techniques	90.0
Average age of sewer (years)	35
% sewer with separated stormwater and sanitary water	35.0

Cafe in the old city centre near the city hall in Ljubljana. © RossHelen / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 0 WARNING: 2 WATCH: 7

Stress incidents for drought level

SLOVENIA

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	263%
2036-2065	501%
2066-2095	566%
0	600%

Average % change in population directly affected

2006-2035	216%
2036-2065	474%
2066-2095	447%
0	750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

LJUBLJANA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 13 M€

0 — 300M€

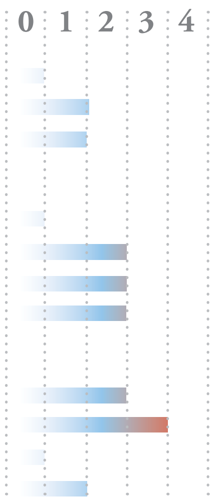
Population directly affected: 482 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

1.4

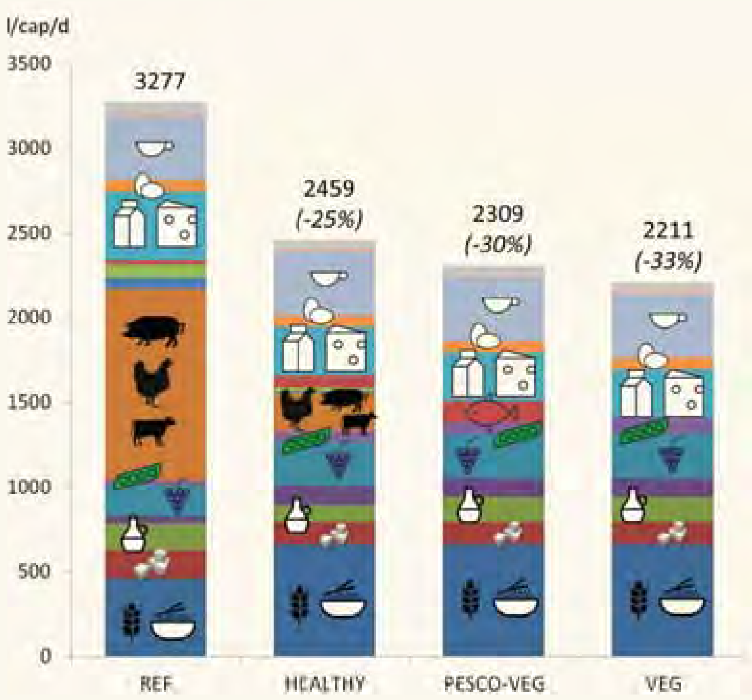


Within this table, lower numbers are better.

LJUBLJANA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Ljubljana. Four diet scenarios are shown. The current diet of the inhabitants of Ljubljana leads to a WF of 3 277 l/cap/d, an amount that exceeds the direct water use of the city (67.3 m^3/cap/year which equals 187 l/cap/d) substantially. A healthy Mediterranean diet leads to a WF of 2 459 l/cap/d, so a reduction of 25%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 30% reduction to 2 309 l/cap/d) and a vegetarian diet (a 33% reduction to 2 211 l/cap/d). Ljubljana's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

Łódź

51°45′00″ N | 19°28′00″ E   *Country: Poland, Region: Łódź*

National Flag

City Flag

Coat of Arms

Modern architecture in the city of Lodz, Poland. © Velishchuk Yevhen / Shutterstock.com | Below: The White Factory, presently the seat of the Central Museum of Textiles, Lodz, Poland. © Mariola Anna S / Shutterstock.com

LODZ

Łódź, with a population of 760 000, is the third largest city of Poland, located near its geographical centre. The city, whose name means 'boat', is situated by two large river catchments, Vistula and Oder. Its dense network of streams, forests and situation on important transcontinental trade routes, helped the city to rapidly industrialise during the 19th century, becoming a major textile centre. The late 20th century decline of the textile industry shifted the city's profile to that of a major centre of post-industrial renewal. Natural capital, including the streams and valleys, is an important element of revitalisation, providing healthy public space and stabilising the city's ecological and hydrological systems. Lódz has a humid continental climate, with warm summers and no strong dry season.

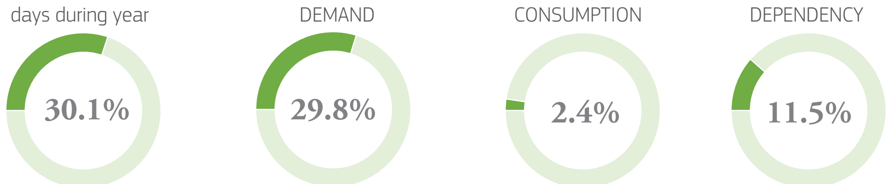
Resident population (x 1 000)	719
Population density (inhabitants/km²)	2 452
Waste production kg/cap/year	320
% Recycling and composting	28
% Incineration with energy recovery	0
% Landfill	71

ENVIRONMENTAL QUALITY

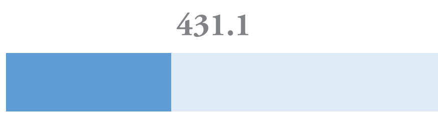
Following advice from the European Regional Centre for Ecohydrology, the city made the health and quality of life of its inhabitants a priority, and a reference point for spatial planning. The city considerably increased the urban quality of life by the creation of a Blue-Green Network using opportunities to integrate stormwater retention and a beneficial connection to the river valleys and green spaces. Łódź successfully enhanced its waste management infrastructure with financial support from the EU Integrity Fund. A communal waste-sorting unit was constructed, a communal organic-waste unit upgraded, and a waste incineration plant is scheduled to be built.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



Evapotranspiration difference (**mm/y**)



ŁÓDŹ

CITY BLUEPRINT ©

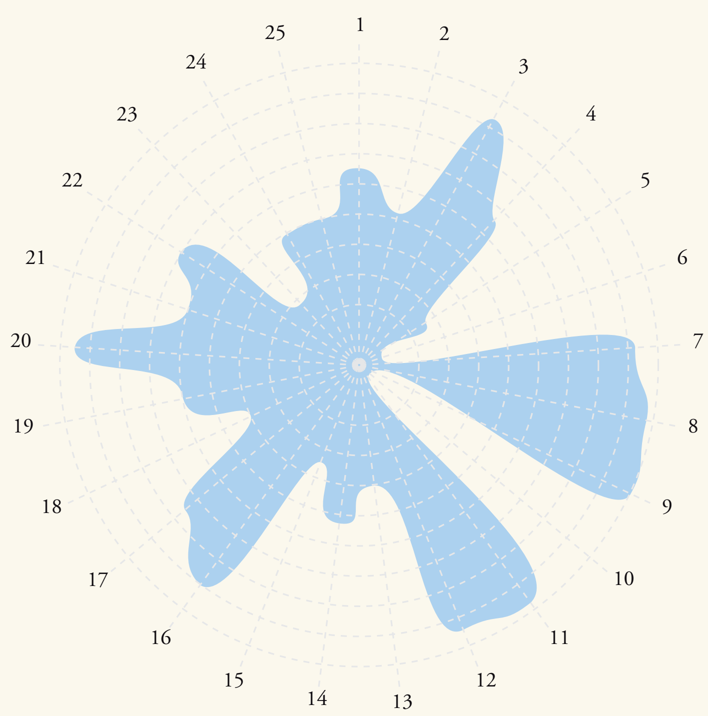
Łódź has good water leakage control. Energy recovery and sewage sludge recycling from wastewater are high. The city can improve its wastewater treatment and solid-waste treatment.

The BCI (Blue City Index) **is 5.2**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **5.2**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	6.5
2	Tertiary WWT	5.2
3	Groundwater Quality	9.3
4	Solid Waste Collected	6.7
5	Solid Waste Recycled	2.8
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	9.2
8	Access to Sanitation	9.8
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	9.7
12	Sewage Sludge Recycling	9.5
13	WWT Energy Efficiency	4.0
14	Average Age Sewer	5.2
15	Operation Cost Recovery	3.3
16	Water System Leakages	9.0
17	Stormwater Separation	7.5
18	Green Space	4.0
19	Climate Adaptation	6.0
20	Drinking Water Consumption	9.4
21	Climate Robust Buildings	6.0
22	Management and Action Plans	7.0
23	Public Participation	2.9
24	Water Efficiency Measures	5.0
25	Attractiveness	5.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Freedom Square in Lodz. © Avillfoto / Shutterstock.com | Below: Piotrkowska Street in Lodz. © Mariola Anna S / Shutterstock.com

WATER BASICS

Water demand has fallen by more than half, coinciding with economic restructuring and a fall in population. Stormwater management is today the biggest water challenge in Łódź. Large parts of the city have combined sewers that pollute rivers during storms, lower the treatment efficiency of the wastewater treatment plant during wet weather and lead to parts of the city being badly affected by flooding.

Annual average rainfall (mm)	610
Daily average air temperature (°C)	8.0
% of blue and green area	28.7
% of soil sealed	48.7
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	7.0

POLAND

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 158%

2036-2065 94%

2066-2095 120%

0 600%

Average % change in population directly affected

2006-2035 133%

2036-2065 73%

2066-2095 93%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DRINKING WATER

Lodz features among the best and cheapest drinking water supplies in Poland, 90% derived from deep wells. It is treated at three stations in Lodz, Tomaszow and podłódzkim Kalinku. Thirty-five wells are located in the city, in twenty of which the water is of such high quality it does not require treatment.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	92.0
% leakage rate water distribution system	5.0
Drinking water consumption (m^3/cap/year)	58.4
Drinking water consumption (litres/cap/day)	162

LODZKIE

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 5.7 M€

0 300M€

Population directly affected: 363 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

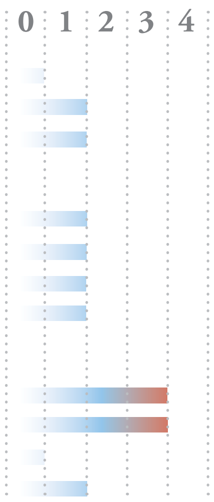
WASTEWATER

Łódź is serviced by a mix of two wastewater systems - combined sewers in the centre and separated sewers in the suburbs. The industrial and domestic sewage from about 80% of the population, as well as stormwater in combined sewers, are conveyed to the central city wastewater treatment plant. After physical and biological treatment, high-quality treated wastewater is discharged into the Ner river.

% population connected to at least secondary wastewater treatment	65.0
% population connected to tertiary wastewater treatment	52.0
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	34
% sewer with separated stormwater and sanitary water	75.0

TRENDS & PRESSURES

1.2

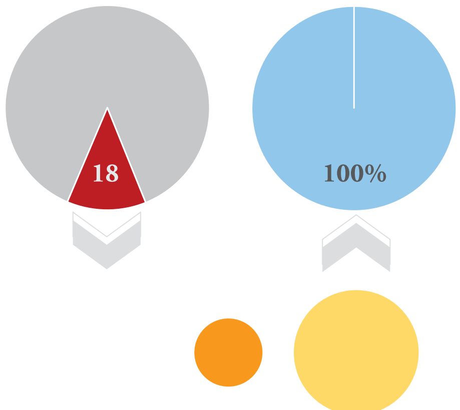


Within this table, lower numbers are better.

Historic Poznanski Palace, Lodz.
© Velishchuk Yevhen / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



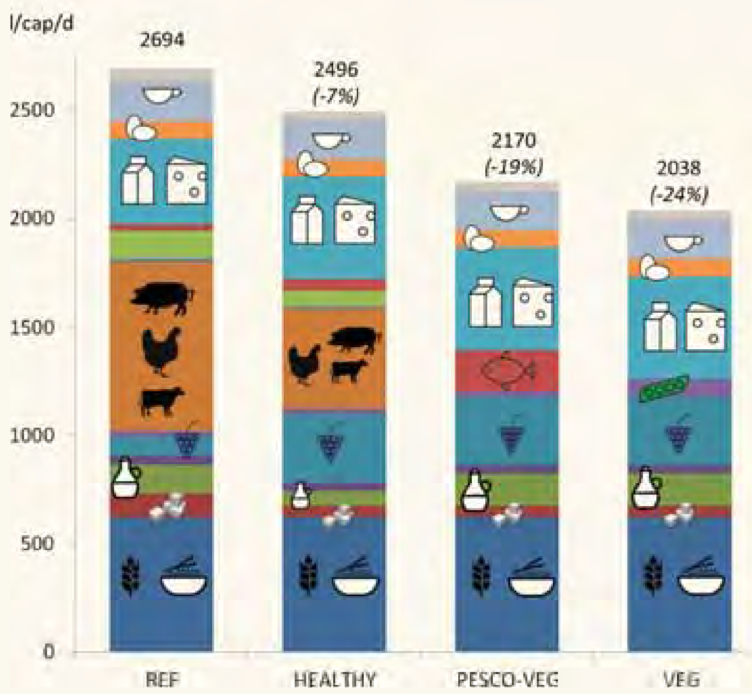
ALERT: 0 WARNING: 7 WATCH: 11

Stress incidents for drought level

ŁÓDŹ

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Łódź. Four diet scenarios are shown. The current diet of the inhabitants of Łódź leads to a WF of 2 694 l/cap/d, an amount that exceeds the direct water use of the city (58.4 m^3/cap/year which equals 162 l/cap/d) substantially. A healthy diet, as recommended by national Polish dietary guidelines (zasady racjonalnego żywienia), leads to a WF of 2 496 l/cap/d, so a reduction of 7%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 19% reduction to 2 170 l/cap/d) and a vegetarian diet (a 24% reduction to 2 038 l/cap/d). Łódź's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

London

51°30′30″ N | 0°07′32″ W   *Country: United Kingdom, Region: Greater London*

National Flag

Big Ben and Houses of parliament at calm sunny morning. © S.Borisov / Shutterstock.com | Below: People stroll in Oxford Circus in London. © pcruciatti / Shutterstock.com

LONDON

London, as part of Greater London, is one of nine regions of England. Founded 2000 years ago by the Romans as Londinium, it is now the capital of England and the UK. The city has been Western Europe's largest city for centuries, and is by far the largest in the UK, with a population of 8.17 million. Central London is dominated by the River Thames, the UK's longest river. Crossing the city from west to east, it characterises the metropolis, helping to make London once the world's largest port, and still the UK's second largest.

London is a leading global city and international financial centre. London has a temperate oceanic climate, typical of the southern UK. Despite its reputation as a rainy city, London receives less precipitation than many other European cities, for example, Rome and Naples.

Resident population (x 1 000)	8 167
Population density (inhabitants/km^2)	5 131
Waste production kg/cap/year	530
% Recycling and composting	40
% Incineration with energy recovery	11
% Landfill	48

ENVIRONMENTAL QUALITY

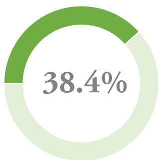
With a significant percentage of green space, London has been defined as 'one of the World's Greenest Cities'. It has a strong track record in sustainable waste management, and the City of London (the original historic heart and now financial centre of the city) was the first London Authority to sort and recycle waste. The Clean City Awards Scheme for best practice in sustainable waste management for businesses has been running successfully since 1994.

Like all large cities, London struggles with air pollution and has imposed limits and restrictions on car and commercial vehicles. Many of its 33 boroughs implement a wide range of additional measures, including citizen engagement, to reduce levels of local pollution.

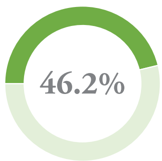
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

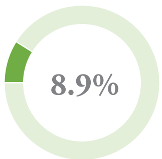
% SOIL WATER STRESS days during year



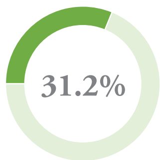
W.E.I. DEMAND



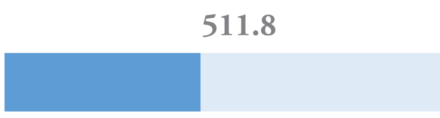
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



LONDON

CITY BLUEPRINT ©

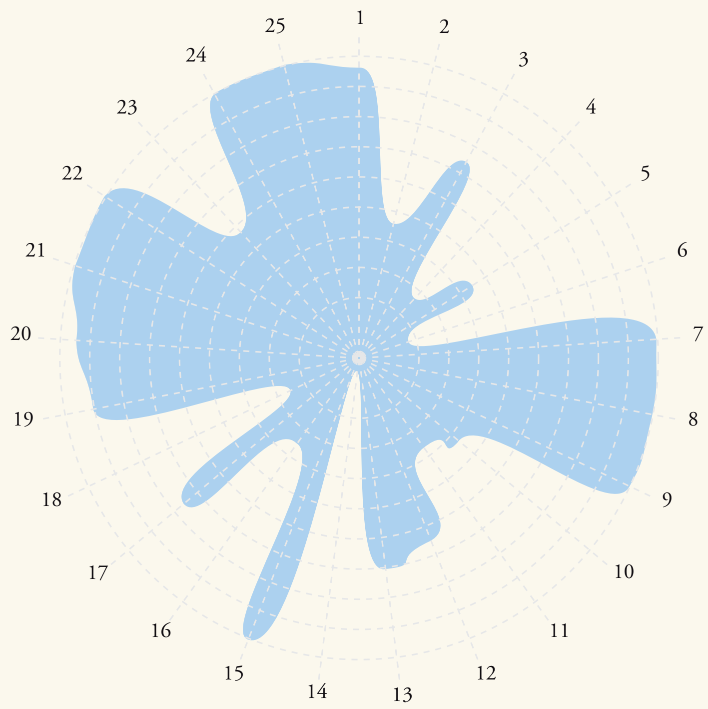
London has sophisticated climate change adaptation plans and low levels of drinking water consumption. However, solid waste treatment and wastewater treatment as well as infrastructure separation and refurbishment need considerable improvements.

The BCI (Blue City Index) **is 5.3**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **5.3**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.7
2	Tertiary WWT	4.7
3	Groundwater Quality	7.4
4	Solid Waste Collected	2.9
5	Solid Waste Recycled	4.5
6	Solid Waste Energy Recovered	1.9
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	4.2
11	Energy Recovery	3.8
12	Sewage Sludge Recycling	6.5
13	WWT Energy Efficiency	7.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	10.0
16	Water System Leakages	3.4
17	Stormwater Separation	0.0
18	Green Space	2.6
19	Climate Adaptation	9.0
20	Drinking Water Consumption	9.5
21	Climate Robust Buildings	10.0
22	Management and Action Plans	10.0
23	Public Participation	5.8
24	Water Efficiency Measures	10.0
25	Attractiveness	10.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

City of London and Canary Wharf. © QQ7 / Shutterstock.com

WATER BASICS

London's water supply infrastructure developed over centuries in line with the city's growth. Most drinking water (80%) originates from the rivers Thames and Lee, with the remainder abstracted from external groundwater sources. London is where Dr John Snow in 1854 first discovered that cholera was spread by polluted drinking water, eventually leading to routine disinfection of drinking water worldwide.

Annual average rainfall (mm)	750
Daily average air temperature (°C)	10.3
% of blue and green area	24.2
% of soil sealed	45.4
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	14.7

DRINKING WATER

London's drinking water has been rated the best in the UK by scientists, with water in the Thames region reported to have passed stringent quality tests 99.98% of the time. In urban areas, the most significant risk to public health is exposure to lead from old pipeworks in older properties. In 2010, London got the UK's first desalinisation plant for emergency contingency.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	33.0
Drinking water consumption (m^3/cap/year)	56.7
Drinking water consumption (litres/cap/day)	157

WASTEWATER

London's modern sewer system was first developed in the 1860s, making one of the most significant contributions to the health and quality of life for citizens. Now owned and operated by Thames Water (also the main drinking water supplier), it serves almost all of Greater London. Today, major investments are ongoing to upgrade the system and to ensure it can meet the population and demands of the 21st century.

% population connected to at least secondary wastewater treatment	96.5
% population connected to tertiary wastewater treatment	47.5
% wastewater that is treated with nutrient-recovering techniques	43.1
% wastewater that is treated with energy-recovering techniques	39.3
Average age of sewer (years)	90
% sewer with separated stormwater and sanitary water	0.0

Canary Wharf Underground station in front of business buildings . © Cristian Teichner / Shutterstock.com

UNITED KINGDOM

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 46%

2036-2065 81%

2066-2095 268%

0 600%

Average % change in population directly affected

2006-2035 48%

2036-2065 75%

2066-2095 331%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

INNER LONDON-WEST

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 25 M€

0 300M€

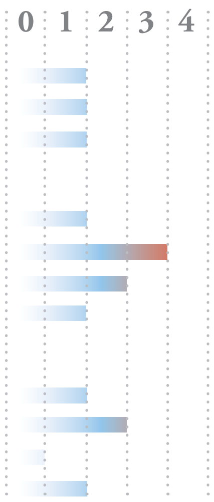
Population directly affected: 2557 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

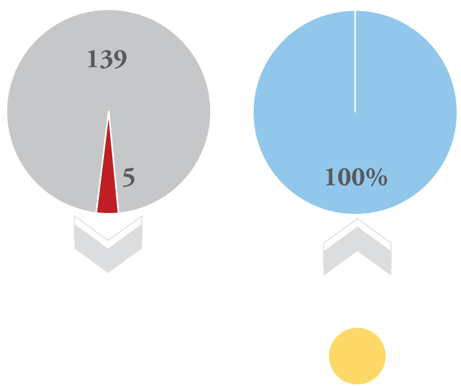
1.3



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



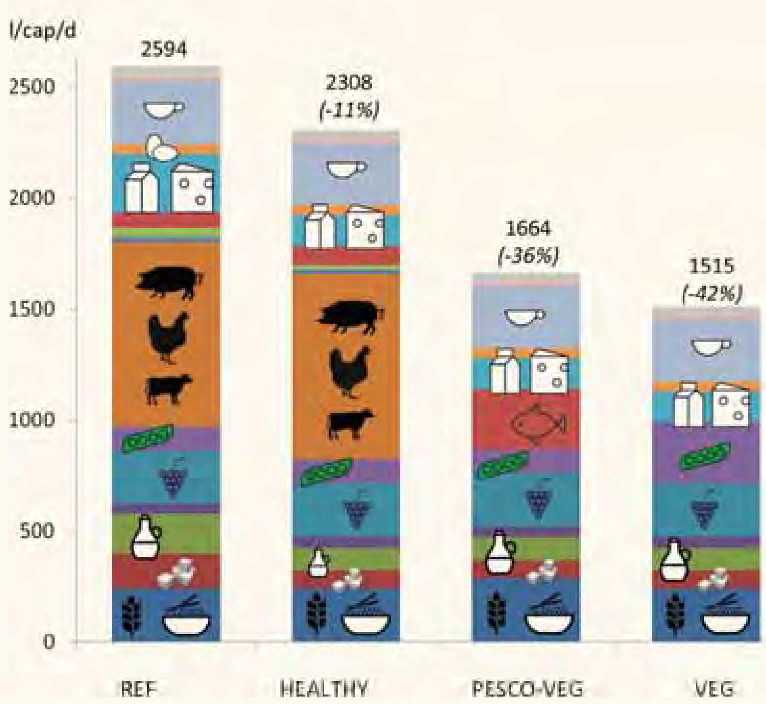
ALERT: 0 WARNING: 0 WATCH: 5

Stress incidents for drought level

LONDON

WATER FOOTPRINT

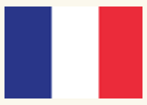
- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for London. Four diet scenarios are shown. The current diet of the inhabitants of London leads to a WF of 2 594 l/cap/d, an amount that exceeds the direct water use of the city (56.7 m^3/cap/year which equals 157 l/cap/d) substantially. A healthy diet, as recommended by national UK dietary guidelines (The Eatwell Guide), leads to a WF of 2 308 l/cap/d, so a reduction of 11%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 36% reduction to 1 664 l/cap/d) and a vegetarian diet (a 42% reduction to 1 515 l/cap/d). London's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

Lyon


National Flag


City Flag


Coat of Arms

45°44′54″ N | 4°50′48″ E   *Country: France, Region: Auvergne-Rhône-Alpes*

View of Lyon from the top of Notre Dame de Fourviere. © prochasson frederic / Shutterstock.com | Below: Sunrise over the city of Lyon, France. © Sander van der Werf / Shutterstock.com

LYON

Lyon is the third largest city in France and has a history of more than 20 centuries. The central city has a population of almost 500 000 and the wider metropolitan area about 2.1 million. Situated in eastern France at the confluence of the rivers Rhône and Saône, Lyon is a major centre for banking, the chemical, pharmaceutical and biotech industries and the software industry, especially video games. It is a major international traffic hub with an airport handling nearly 8 million passengers per year.

Its location, quality of life and economic condition help rate Lyon as one of the most attractive French cities.
Lyon lies in the transition zone between temperate oceanic climates to the north, a warm continental climate to the east, and the subtropical Mediterranean climate to the south.

Resident population (x 1 000)	491
Population density (inhabitants/km²)	10 263
Waste production kg/cap/year	530
% Recycling and composting	37
% Incineration with energy recovery	34
% Landfill	28

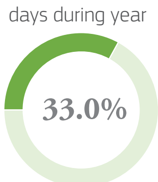
ENVIRONMENTAL QUALITY

Lyon is proactive in urban sustainability. To promote attractive living conditions and sustainable business opportunities, the city invests in clean technology, green buildings and recycling of household and industrial waste.
Each new project in the Greater Lyon area must meet certain sustainability requirements, and is subject to a consultation on its environmental performance. These standards are also required for new industrial parks, of which a new eco-friendly park is being built. The concept of 'Habitat Durable' (sustainable home) was introduced in 2012, and since then over 11 000 homes have been designed to meet minimum sustainability standards. A similar 'Bureau Durable' concept is also in place for businesses.

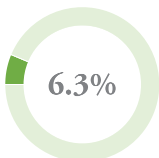
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

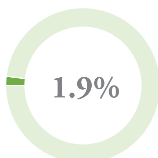
% SOIL WATER STRESS days during year



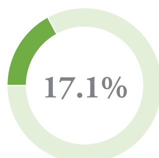
W.E.I. DEMAND



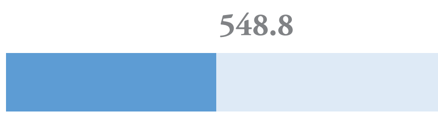
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



LYON

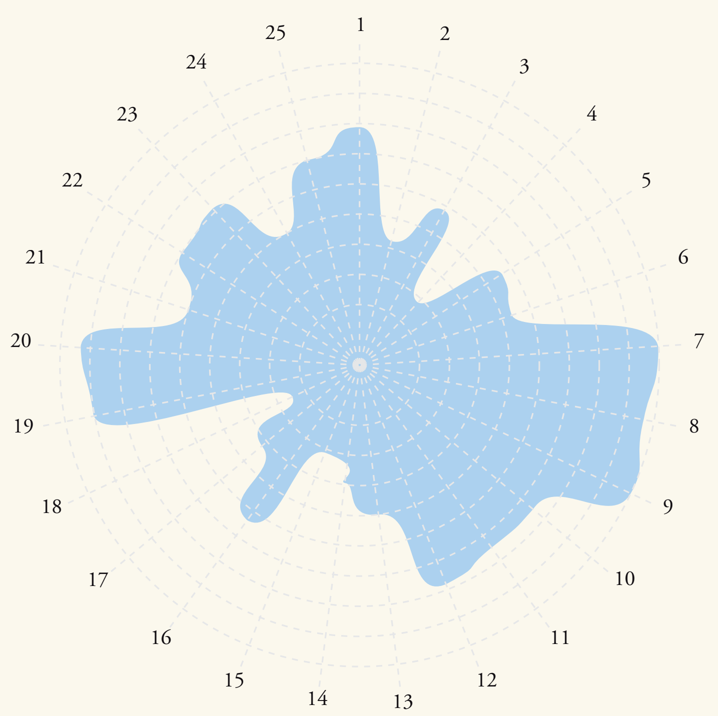
CITY BLUEPRINT ©

Lyon's level of drinking water consumption is low, and energy and nutrients are largely recovered from wastewater. Yet, climate adaptation plans, green space, water leakages and solid waste treatment can still be improved.

The BCI (Blue City Index) **is 6.0**

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).
The Blue City Index is **6.0**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	7.9
2	Tertiary WWT	4.2
3	Groundwater Quality	5.9
4	Solid Waste Collected	2.9
5	Solid Waste Recycled	5.6
6	Solid Waste Energy Recovered	5.4
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.6
9	Drinking Water Quality	10.0
10	Nutrient Recovery	7.5
11	Energy Recovery	7.5
12	Sewage Sludge Recycling	7.9
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	4.0
15	Operation Cost Recovery	3.1
16	Water System Leakages	6.3
17	Stormwater Separation	4.1
18	Green Space	2.5
19	Climate Adaptation	9.0
20	Drinking Water Consumption	9.2
21	Climate Robust Buildings	6.0
22	Management and Action Plans	7.0
23	Public Participation	7.1
24	Water Efficiency Measures	5.0
25	Attractiveness	7.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Panoramic view of Lyon with Saone river. © Aurelien Laforet / Shutterstock.com

WATER BASICS

Water is an important feature of Lyon, with two significant rivers, the Rhône and Saône, meeting at its heart. Protecting river quality is therefore an important aim of the municipality. Drinking water originates mainly from the Crépieux-Charmy wellfield on the north-eastern edge of the city. With 114 boreholes, it is the largest wellfield in Europe producing up to 420 000 m³/day from groundwater recharged by the Rhone.

Annual average rainfall (mm)	770
Daily average air temperature (°C)	11.0
% of blue and green area	23.9
% of soil sealed	55.2
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	28.4

DRINKING WATER

Lyon's drinking water is of high quality. The groundwater is naturally of high quality due to natural filtration by the aquifer. Water treatment protects the quality, mainly from microbiological risks, once in the distribution and storage network (totaling 4 000 km of pipes). The aquifers are constantly replenished by the high flowing Rhône, and therefore at minimal risk of water shortage.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	99.5
% leakage rate water distribution system	18.6
Drinking water consumption (m^3/cap/year)	62.1
Drinking water consumption (litres/cap/day)	173

WASTEWATER

The wastewater system of Lyon comprises 12 treatment plants with a capacity of over 1 million m³/day, and a total infrastructure length of 3 193 km, of which approximately 60% is combined. Treated wastewater, by both physical and biological processes, is discharged to the rivers, complying with strict environmental standards. Collected solid sludge is 100% incinerated. 95% is treated for energy and nutrient recovery.

% population connected to at least secondary wastewater treatment	79.0
% population connected to tertiary wastewater treatment	42.0
% wastewater that is treated with nutrient-recovering techniques	94.9
% wastewater that is treated with energy-recovering techniques	94.9
Average age of sewer (years)	40
% sewer with separated stormwater and sanitary water	40.6

Place Bellecour statue of King Louis XIV by night.
© prochasson frederic / Shutterstock.com

FRANCE

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 176%

2036-2065 203%

2066-2095 304%

0 600%

Average % change in population directly affected

2006-2035 206%

2036-2065 215%

2066-2095 329%

0 750%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

RHÔNE-ALPES

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 83 M€

0 300M€

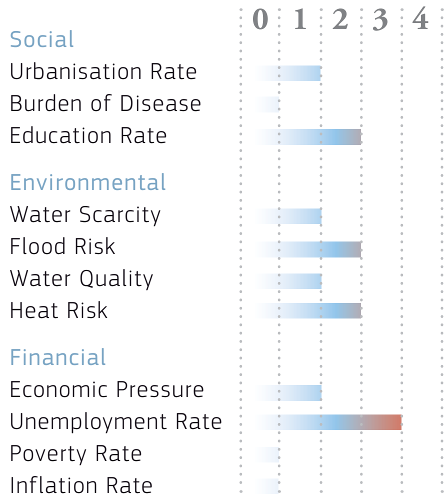
Population directly affected: 4526 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

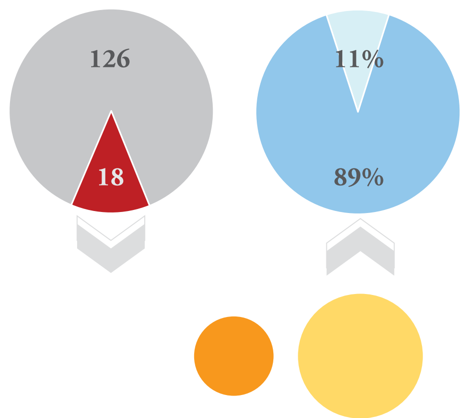
1.3



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



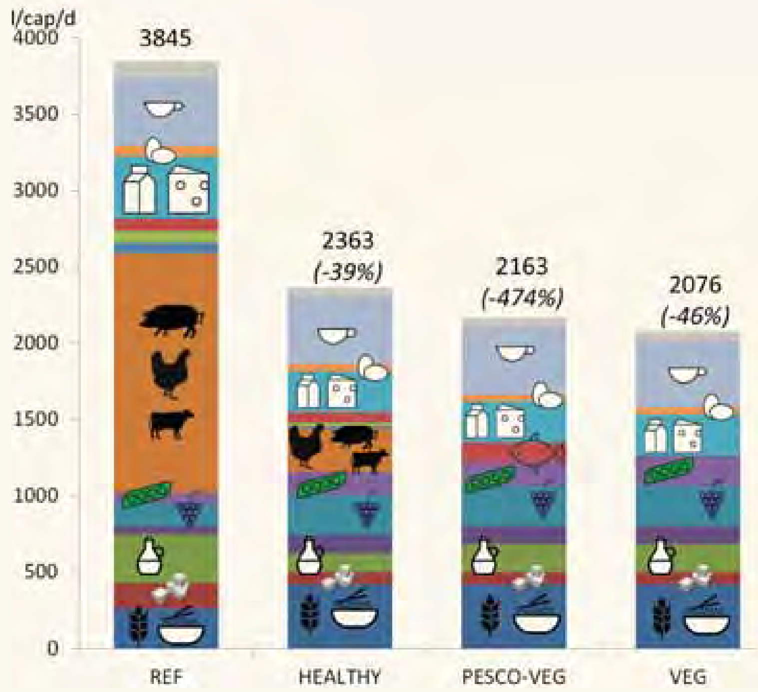
ALERT: 0 WARNING: 7 WATCH: 11

Stress incidents for drought level

LYON

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Lyon. Four diet scenarios are shown. The current diet of the inhabitants of Lyon leads to a WF of 3 845 l/cap/d, an amount that exceeds the direct water use of the city (62.1 m³/cap/year which equals 173 l/cap/d) substantially. A healthy Mediterranean diet leads to a WF of 2 362 l/cap/d, so a reduction of 39%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 44% reduction to 2 163 l/cap/d) and a vegetarian diet (a 46% reduction to 2 076 l/cap/d). Lyon's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

Maastricht

50°50′53″ N | 5°41′20″ E   *Country: The Netherlands, Region: Limburg*


National Flag


City Flag


Coat of Arms

Maastricht at dusk. © pepijn thijsse / Shutterstock.com | Below: Historical center of dutch city maastricht is full of narrow streets with bars, restaurants and resting areas. © trabantos / Shutterstock.com

MAASTRICHT

The southernmost city of the Netherlands, Maastricht lies on the River Meuse (Maas in Dutch), close to the Belgian and German borders. The city became famous as host for the signing of the 1992 Treaty of Maastricht, which created the European Union, European citizenship and set the foundation for the euro common currency. Maastricht is an international city with 120 000 inhabitants, close to other international cities such as Aachen, Düsseldorf, Liège, Brussels and Antwerp.

The city hosts a number of European and international organisations that provide an increasing number of employment opportunities, and has an international university of 16 000 students, of which 47% are foreign.

Maastricht has an oceanic climate, but due to its more inland location among hills, summers tend to be stable and warm.

ENVIRONMENTAL QUALITY

The air quality in Maastricht and its surroundings is of general concern for its inhabitants. The main source of air pollution is traffic emissions which are held like a blanket over the city by the surrounding hills. To improve the situation, the city centre has been established as a Low Emission Zone with restrictions on local transportation.

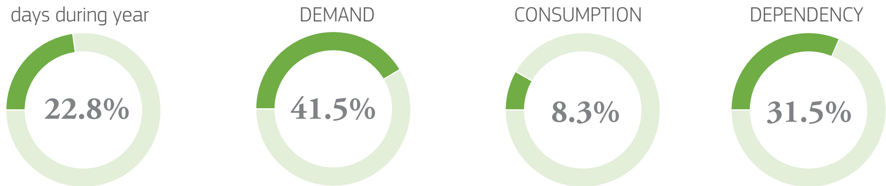
As regards waste, Maastricht is a leader in the Netherlands for waste separation and recycling. The city aims to be carbon-neutral by 2030, and has set itself the goal of achieving a carbon balance in its governing bodies and organisations. Maastricht aims to achieve these targets while maintaining an affordable and reliable energy supply.

Resident population (x 1 000)	123
Population density (inhabitants/km²)	2 037
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

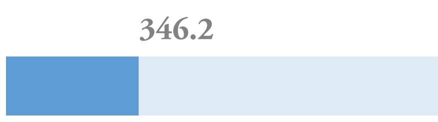
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year | W.E.I. DEMAND | W.E.I. CONSUMPTION | Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



MAASTRICHT

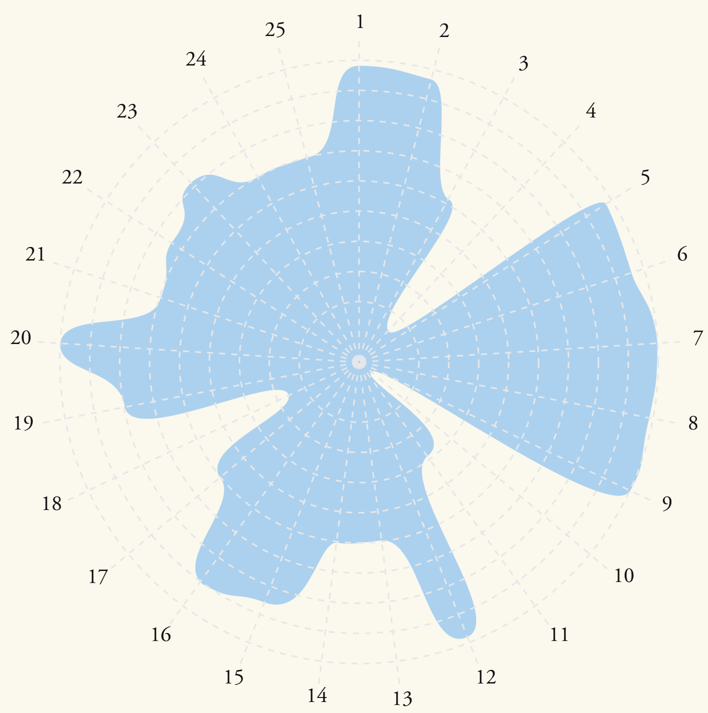
CITY BLUEPRINT ©

Maastricht's water consumption and water leakages are very low. The city can become a leading one in terms of sustainable water use by reducing its solid-waste production, increasing its nutrient-recovery from wastewater and by further increasing its blue-green infrastructure.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **6.6**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	6.1
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	4.0
12	Sewage Sludge Recycling	9.9
13	WWT Energy Efficiency	6.0
14	Average Age Sewer	6.0
15	Operation Cost Recovery	8.5
16	Water System Leakages	9.0
17	Stormwater Separation	6.0
18	Green Space	2.6
19	Climate Adaptation	8.0
20	Drinking Water Consumption	10.0
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.5
23	Public Participation	8.1
24	Water Efficiency Measures	7.0
25	Attractiveness	7.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., Chandy P.C., 2013. The city blueprint: Experiences with the implementation of 24 indicators to assess the sustainability of the urban water cycle. Water Science and Technology: Water Supply, 13.3, 769-78
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

St. Servaas bridge and old city in Maastricht. © Henk Paul / Shutterstock.com

WATER BASICS

The river Meuse/Maas characterises the city, including its name. Following floods in 1993 and 1995, Flanders and the Netherlands jointly carried out large-scale works to improved protection levels. The river's flow regime is controlled by rainfall, and hence water quality and quantity are fairly susceptible to drought events as seen in 2003. It is also dependent on the management practices of other countries through which it flows (France and Belgium).

Annual average rainfall (mm)	780
Daily average air temperature (°C)	10.0
% of blue and green area	24.3
% of soil sealed	54.8
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	49.0

DRINKING WATER

Maastricht is served by the publicly owned Limburg Water Company (WML). Approximately 75% of supply is from groundwater, and 25% from the River Meuse. Like the rest of the Netherlands, careful management allows chlorination to be kept to a minimum, but softening is required. Along the border, WML also purchases water from Germany. The whole supply network is interconnected via a pipeline grid totaling 85 000 km.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	5.0
Drinking water consumption (m^3/cap/year)	45.2
Drinking water consumption (litres/cap/day)	126

WASTEWATER

As for water supply, wastewater is managed across the Limburg province by a single public utility (Waterschapbedrijf Limburg, WBL). WBL has 18 wastewater treatment plants across the province, annually treating 140 Mm^3 from homes, businesses and industry. Biogas is extracted for energy generation, sludge is dried and processed as fuel for cement kilns in Maastricht, and the cleaned wastewater is returned to streams and rivers in Limburg.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater that is treated with nutrient-recovering techniques	0.5
% wastewater that is treated with energy-recovering techniques	40.0
Average age of sewer (years)	30
% sewer with separated stormwater and sanitary water	60.0

Cafe on the banks of the Meuse river.
© Pecold / Shutterstock.com

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	229%
2036-2065	22%
2066-2095	296%
0	600%

Average % change in population directly affected

2006-2035	255%
2036-2065	42%
2066-2095	340%
0	750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

LIMBURG

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 8.6 M€

0 — 300M€

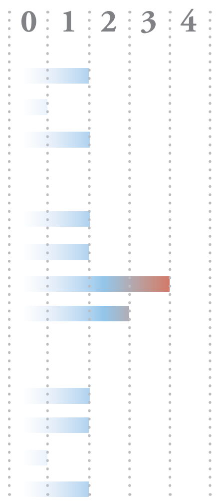
Population directly affected: 781 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

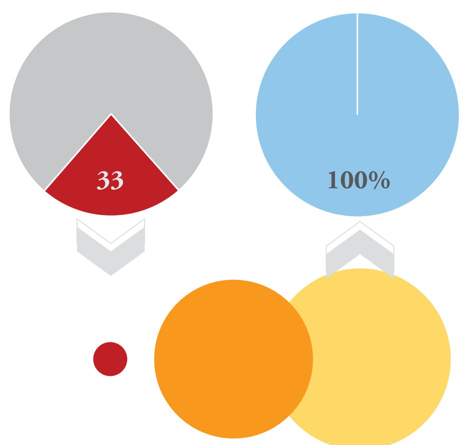
1.0



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



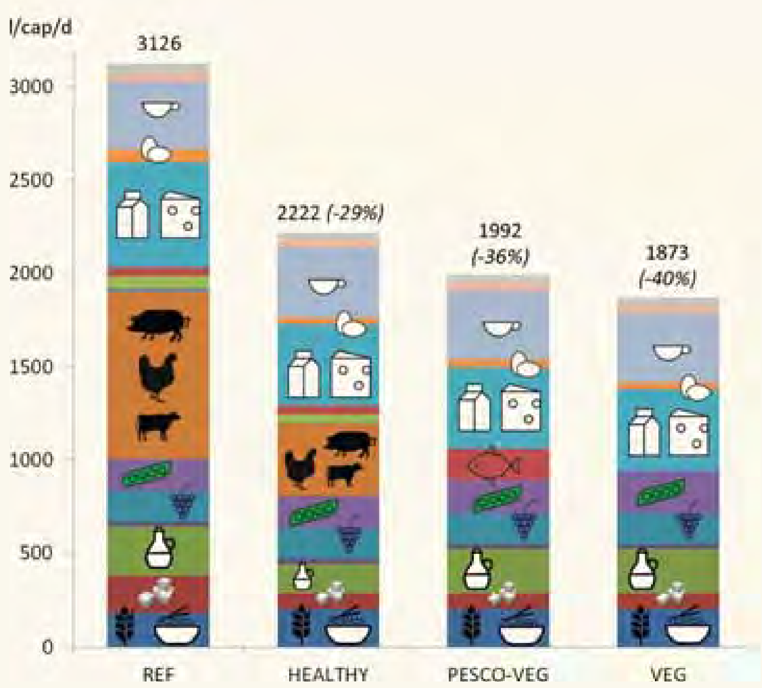
ALERT: 3 WARNING: 14 WATCH: 16

Stress incidents for drought level

MAASTRICHT

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Maastricht. Four diet scenarios are shown. The current diet of the inhabitants of Maastricht leads to a WF of 3 126 l/cap/d, an amount that exceeds the direct water use of the city (45.2 m^3/cap/year which equals 126 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2 222 l/cap/d, so a reduction of 29%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 36% reduction to 1 992 l/cap/d) and a vegetarian diet (a 40% reduction to 1 873 l/cap/d). Maastricht's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565, 232–239

Malmö

55°36′21″ N | 13°00′02″ E   *Country: Sweden, Region: Scania*

National Flag

Coat of Arms

Malmo West Harbor Area Cityscape with Turning Torso as Distinctive Landmark. With its 190 m, it is the Largest Building in Sweden and the whole Scandinavia. © igorstevanovic / Shutterstock.com

Below: Lighthouse in Malmo, Sweden, © Arndale / Shutterstock.com

MALMÖ

Malmö is the commercial centre of southern Sweden and an international city. It is the third largest city in Sweden with 300 000 inhabitants, and with relative diversity represented by approximately 170 different nationalities. Malmö is undergoing a transition from being an industrial city to a city of knowledge. Older industries have been replaced by investments in new technology and high-calibre training programmes. Malmö is part of the transnational Øresund Region connected by the Øresund Bridge to Copenhagen, Denmark.

Malmö has two industrial harbours, and over 400 km of cycle paths. More than 40% of all local travel is by bicycle.

Featuring an oceanic climate, dominated by the Gulf Stream, rainfall is light to moderate throughout the year, with 169 wet days and averaging 700 mm precipitation.

Resident population (x 1 000)	317
Population density (inhabitants/km²)	2 023
Waste production kg/cap/year	460
% Recycling and composting	47
% Incineration with energy recovery	51
% Landfill	1

ENVIRONMENTAL QUALITY

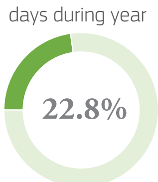
For more than a decade Malmö has engaged in progressive investment in environmental and climate issues. It aims to be carbon-neutral by 2020, and to run 100% on renewable energy by 2030. A key aspect is engagement with its citizens, industry, colleges, universities and others. Malmö also cooperates widely with other cities, primarily in Europe. Malmö optimises use of land surfaces, for example, by systematic building of open runoff systems to decrease impacts of sealed surfaces. Other priorities are waste reduction, sustainable building and energy efficiency. The city's progressive environmental agenda pays off, not only from an ecological perspective, but also from social and economic perspectives.

WATER DEMAND & AVAILABILITY

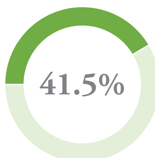
Based on the JRC's LISFLOOD model

W.E.I. stands for Water Exploitation Index

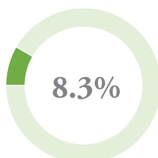
% SOIL WATER STRESS days during year



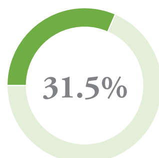
W.E.I. DEMAND



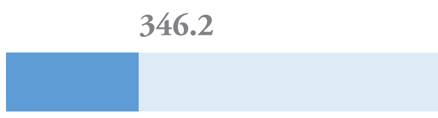
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



MALMÖ

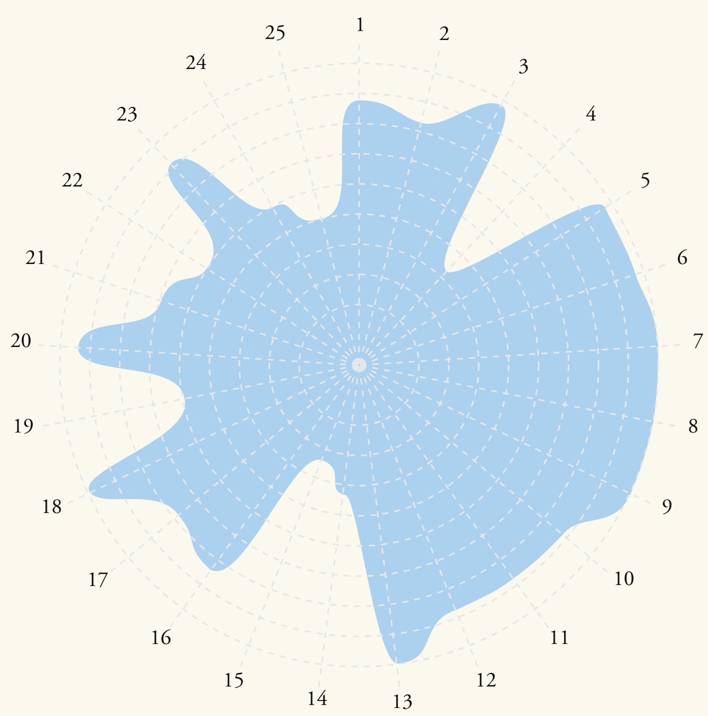
CITY BLUEPRINT ©

Malmö has an outstanding solid-waste and wastewater treatment regime that includes full recycling, energy recovery and nutrient recovery. Climate adaptation policy and the reduction of solid-waste production need further attention.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **7.7**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	8.7
2	Tertiary WWT	8.3
3	Groundwater Quality	9.8
4	Solid Waste Collected	4.1
5	Solid Waste Recycled	9.7
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	8.7
11	Energy Recovery	8.7
12	Sewage Sludge Recycling	8.7
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	4.3
15	Operation Cost Recovery	3.3
16	Water System Leakages	8.4
17	Stormwater Separation	7.9
18	Green Space	10.0
19	Climate Adaptation	6.0
20	Drinking Water Consumption	9.3
21	Climate Robust Buildings	7.0
22	Management and Action Plans	6.0
23	Public Participation	9.2
24	Water Efficiency Measures	6.0
25	Attractiveness	5.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Mottaghi M., Aspegren H., Jönsson K., 2015. The necessity for re-thinking the way we plan our cities with the focus on Malmö - Towards urban-planning based urban runoff management. Vatten – Journal of Water Management and Research, 71, 37–44
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Malmo Triangeln Underground Train Station Opened in December 2010 as a part of the newly built City tunnel. © igorstevanovic / Shutterstock.com

WATER BASICS

Despite a general water abundance in Sweden, the Skåne Region, where Malmö is situated, has some water provision difficulties. The city is also affected by heavy rainfall events which cause flash floods and jeopardise local transport. Storm water management, using green-blue areas, has become a key priority for the city, with open-channel solutions in place of closed pipes, now prioritised for new developments.

Annual average rainfall (mm)	700
Daily average air temperature (°C)	7.0
% of blue and green area	49.3
% of soil sealed	41.5
% flooded by 1-m sea-level rise	1.2
% flooded by 1-m river-level rise	15.0

DRINKING WATER

Malmö's drinking water is medium hard and of high quality. The total supply network includes abut 900 km of pipeline. Groundwater aquifers in Vombsjön and Grevieparken provide more than 95% of the city's water supply.

The water supply utility is VA SYD, a public agency, which also provides wastewater, storm water management systems, and waste collection and disposal services across southern Sweden.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	8.0
Drinking water consumption (m^3/cap/year)	60.7
Drinking water consumption (litres/cap/day)	168

WASTEWATER

The Sjölunda Wastewater Treatment Plant is situated in the northern part of Malmö Harbour, and treats about 1 350 l/s of wastewater received from the greater part of Malmö. Approximately 300 000 residents are connected to the plant, making it one of Sweden's largest wastewater treatment plants. Malmö has both combined and separated sections of the sewer network, including open 'green-blue' systems.

% population connected to at least secondary wastewater treatment	87.0
% population connected to tertiary wastewater treatment	83.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	38
% sewer with separated stormwater and sanitary water	79.0

Petri Bridge in the old town of Malmo.
© Leonid Andronov / Shutterstock.com

SWEDEN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 37%

2036-2065 25%

2066-2095 90%

0 600%

Average % change in population directly affected

2006-2035 31%

2036-2065 12%

2066-2095 68%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

SOUTH SWEDEN

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 12 M€

0 300M€

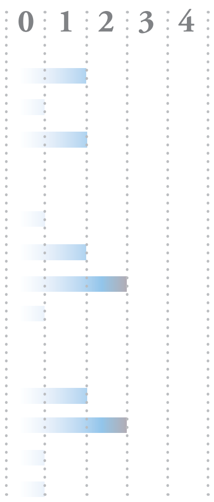
Population directly affected: 287 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

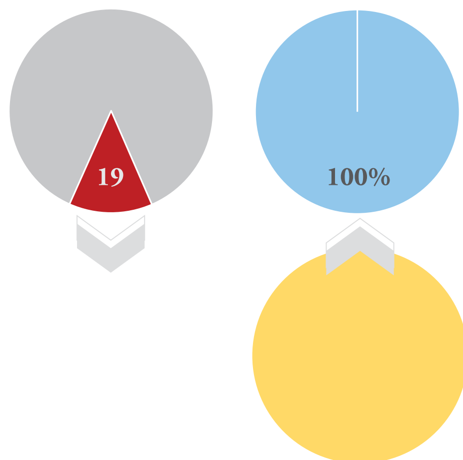
0.7



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



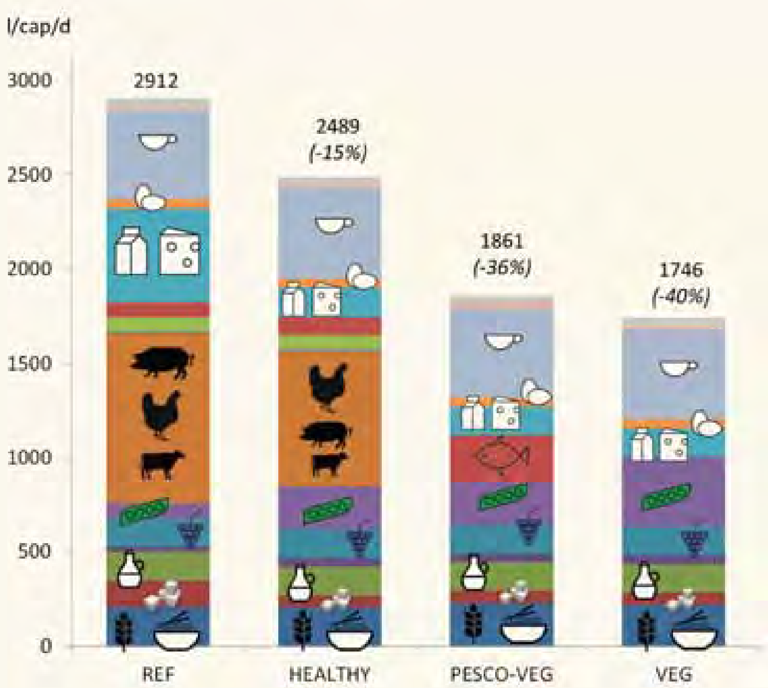
ALERT: 0 WARNING: 0 WATCH: 19

Stress incidents for drought level

MALMÖ

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



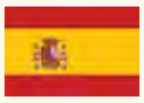
This figure shows the water footprint (WF) related to food consumption for Malmö. Four diet scenarios are shown. The current diet of the inhabitants of Malmö leads to a WF of 2 912 l/cap/d, an amount that exceeds the direct water use of the city (60.7 m^3/cap/year which equals 168 l/cap/d) substantially. A healthy diet, as recommended by the Swedish National Food Agency (Livsmedelsverket), leads to a WF of 2 489 l/cap/d, so a reduction of 15%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 36% reduction to 1 861 l/cap/d) and a vegetarian diet (a 40% reduction to 1 746 l/cap/d). Malmö's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

Manresa

41°43′29″ N | 1°49′35″ E   *Country: Spain, Region: Catalonia*


National Flag


City Flag


Coat of Arms


Basilic of Manresa, Catalonia. © J.Blanco / Shutterstock.com | Below: Old bridge is of Roman origin in Manresa, Catalonia (Spain). The river is Cardener. © Pepj / Shutterstock.com

MANRESA

Manresa has a history of more than one 1 000 years. It is located in the heart of Catalonia, on the Cardener River, not far from Barcelona, and on a strategic regional communication axis. With over 75 000 inhabitants, Manresa has an industrial and commercial tradition, and has an important role as the capital of a wider territory of over 250 000 people in Central Catalonia. Main industrial activities in the town include textile manufacturing, metallurgy, and glass making. Manresa is also home to CTM, a highly qualified Advanced Technological Centre (ATC) with an international reputation in technologies in the scientific and industrial fields.
The climate in Manresa can be defined as humid temperate with hot summers. The city has a mean temperature of 15°C and average annual rainfall of about 600 mm.

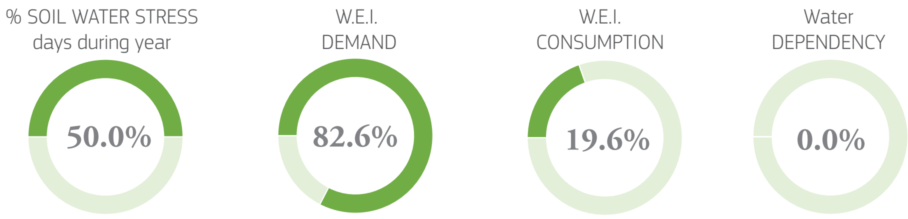
Resident population (x 1 000)	77
Population density (inhabitants/km²)	1 839
Waste production kg/cap/year	500
% Recycling and composting	29
% Incineration with energy recovery	8
% Landfill	63

ENVIRONMENTAL QUALITY

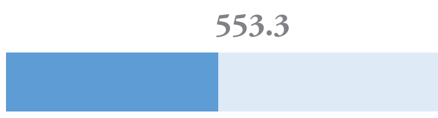
Local initiatives for the environment in Manresa are driven by the Agenda 21 initiative. The city of Manresa promotes the creation of a programme for balanced and sustainable development of urban life, for present and future generations.
Specifically, it targets five priority areas: waste, energy, nature, sustainable administration and information. Indeed, Manresa subscribes an open data policy.
To protect local urban bio-diversity, the city council has established a ‘Green Ring’, which links open spaces around the city to promote social value, environmental landscapes and agricultural production through protection, connection and empowerment.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



Evapotranspiration difference (**mm/y**)



MANRESA

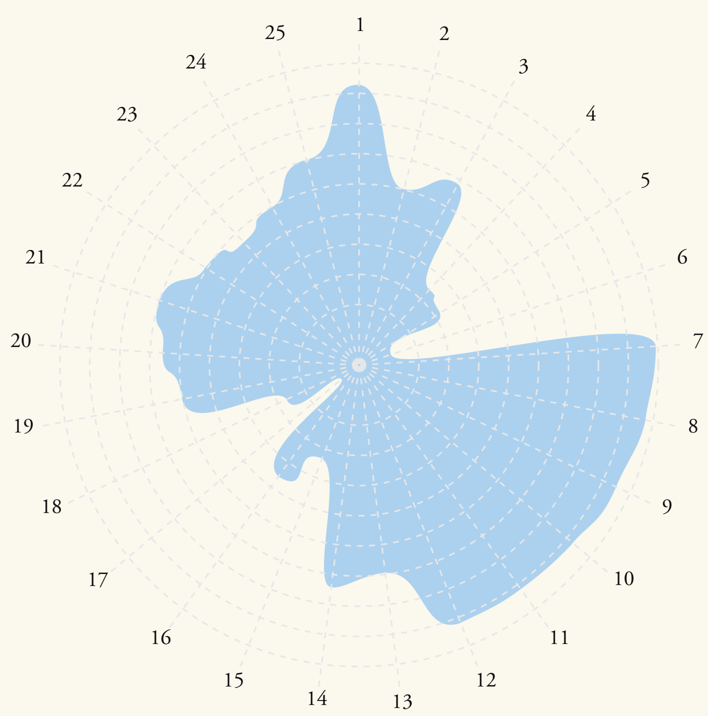
CITY BLUEPRINT ©

Manresa's wastewater treatment is very good. The city can, however, improve with respect to solid-waste treatment, climate adaptation policy, leakage control and more blue-green infrastructure.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **5.6**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.3
2	Tertiary WWT	6.0
3	Groundwater Quality	6.9
4	Solid Waste Collected	3.4
5	Solid Waste Recycled	3.2
6	Solid Waste Energy Recovered	1.1
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.8
9	Drinking Water Quality	9.5
10	Nutrient Recovery	9.3
11	Energy Recovery	9.3
12	Sewage Sludge Recycling	9.3
13	WWT Energy Efficiency	7.0
14	Average Age Sewer	7.4
15	Operation Cost Recovery	3.1
16	Water System Leakages	4.5
17	Stormwater Separation	0.8
18	Green Space	2.8
19	Climate Adaptation	6.0
20	Drinking Water Consumption	6.5
21	Climate Robust Buildings	7.0
22	Management and Action Plans	6.0
23	Public Participation	5.6
24	Water Efficiency Measures	6.0
25	Attractiveness	7.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

La Cova. © J.Blanco / Shutterstock.com

WATER BASICS

The main water supply is from the Llobregat River, via the 26-km Sequia Canal, first constructed in the 14th century. The river has more demand for water than availability. To ensure a reiable supply, a reservoir of capacity of 109 million m³ was built in the upper courses to buffer availability between periods of high and low flow. The raw water is stored a 200 000 m3 reservoir at Manresa.

Annual average rainfall (mm)	571
Daily average air temperature (°C)	15.0
% of blue and green area	25.0
% of soil sealed	57.9
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	6 to 10

DRINKING WATER

Most drinking water originates from surface water, with 87% from the Llobregat and the remaining 13% from local groundwater sources. The total supply network is of 1 200 km length. Drinking water quality is good and in compliance with strict EU regulations. The water distribution system is automatically controlled by a remote control system that connects the various remote stations with the control centre.

% of drinking water samples complying with drinking water regulation	95.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	27.3
Drinking water consumption (m³/cap/year)	122.7
Drinking water consumption (litres/cap/day)	341

WASTEWATER

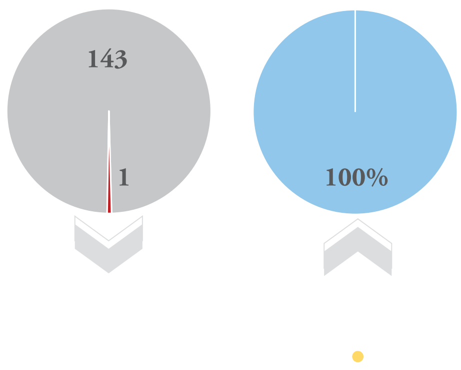
Wastewater is collected and transported to the wastewater treatment plant, where it is treated to a high standard prior to discharge to the Cardener river, a tributary to the Llobregat, thus helping to maintain the local water cycle. There is also additional treatment of sewage sludge to recover nutrients, to create compost for agriculture and collect biogas for electricity supply.

% population connected to at least secondary wastewater treatment	93.0
% population connected to tertiary wastewater treatment	60.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	23
% sewer with separated stormwater and sanitary water	7.9

Abandoned factory in Manresa.
© Marti Garcia Muns / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 0 WARNING: 0 WATCH: 1

Stress incidents for drought level

SPAIN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	45%
2036-2065	89%
2066-2095	123%
0	600%

Average % change in population directly affected

2006-2035	52%
2036-2065	72%
2066-2095	114%
0	750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

CATALONIA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 22 M€

0 300M€

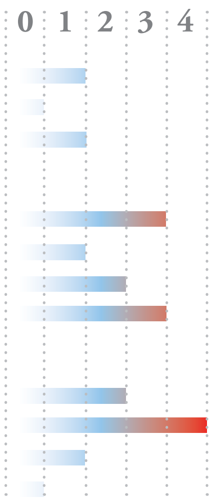
Population directly affected: 1282 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

1.7

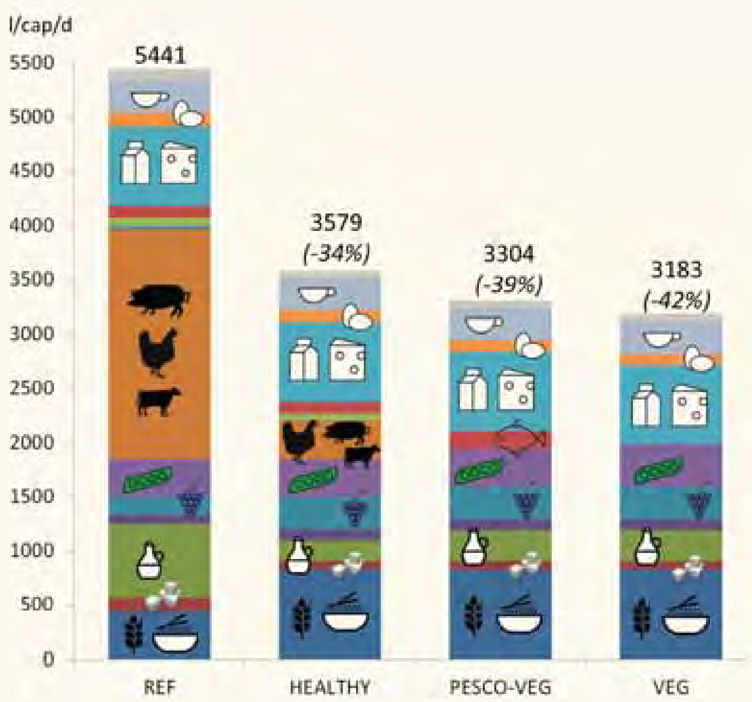


Within this table, lower numbers are better.

MANRESA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



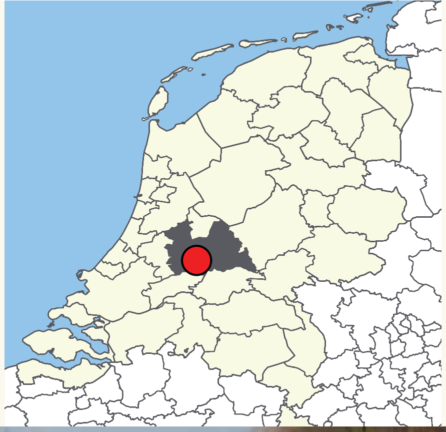
This figure shows the water footprint (WF) related to food consumption for Manresa. Four diet scenarios are shown. The current diet of the inhabitants of Manresa leads to a WF of 5 441 l/cap/d, an amount that exceeds the direct water use of the city (122.7 m³/cap/year which equals 341 l/cap/d) substantially. A healthy Mediterranean diet leads to a WF of 3 579 l/cap/d, so a reduction of 34%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 39% reduction to 3 304 l/cap/d) and a vegetarian diet (a 42% reduction to 3 183 l/cap/d). Manresa's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

Nieuwegein

National Flag City Flag Coat of Arms



52°01′45″ N | 5°04′50″ E Country: *The Netherlands*, Region: *Utrecht*

Canal street in Nieuwegein. © Kees van Leeuwen | Below: Wakeboarder participates in the NWWB wakeboard cable event in Nieuwegein. © Nildo Scoop / Shutterstock.com

NIEUWEGEIN

Nieuwegein, located in the province of Utrecht, has only existed since 1971. It was a planned city (a 'newtown') built to cater for the overflow from the prosperous city of Utrecht, originally made up of the former municipalities of Jutphaas and Vreeswijk.
A green and well-thought-out city, Nieuwegein was built to meet the needs of commuters and their families. It takes advantage from its adjacent waterways: the Lek River, the Amsterdam-Rhine canal and the Merwede canal, and three motorways. Nieuwegein has excellent transport connections, including a light railway connecting it to Utrecht to the north and IJsselstein to the south west.
The climate of Nieuwegein is oceanic, mild, and generally warm and temperate. The average rainfall of 803 mm/y is spread fairly evenly throughout the year.

Resident population (x 1 000)	61
Population density (inhabitants/km²)	2 379
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

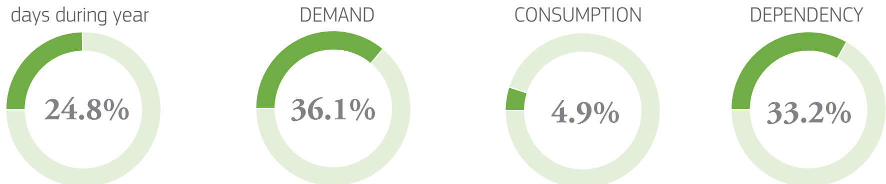
ENVIRONMENTAL QUALITY

As a new and planned city, Nieuwegein has integrated sustainable urban living since its beginning in 1971. With an air quality plan, a climate programme and a Municipal Traffic and Transport strategy, the city is well ahead of many other municipalities. In the next few years, Nieuwegein will execute several water projects described as the "New Waterway". These projects will contribute to a cleaner environment and an improved water balance. The new waterway will be first realised in the district of Zandveld. A separate stormwater system carries rainwater to canals and drains in the neighbourhood. Underground concrete basins will also be constructed for temporary storage of flood waters after heavy rainfall events.

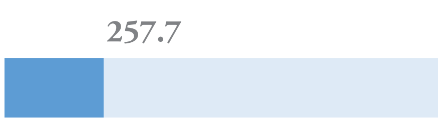
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year — W.E.I. DEMAND — W.E.I. CONSUMPTION — Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



NIEUWEGEIN

CITY BLUEPRINT ©

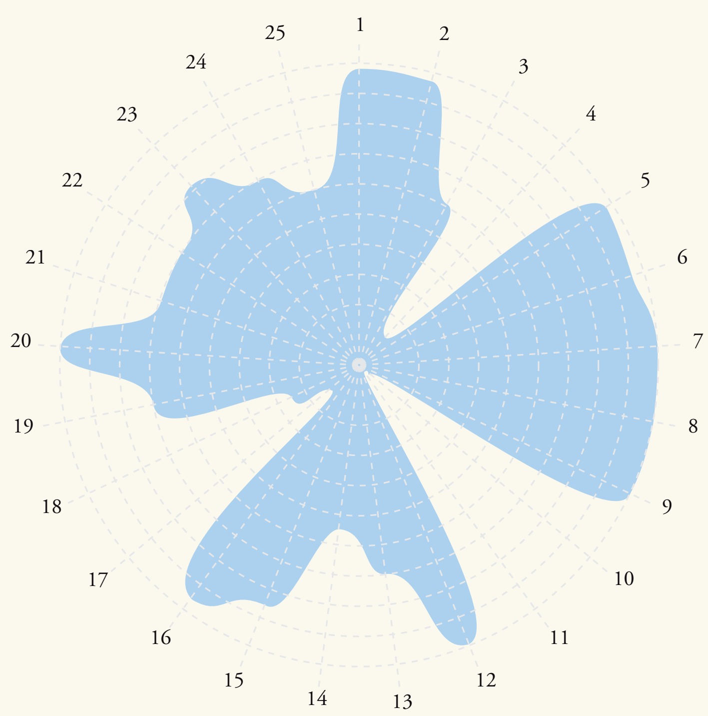
Nieuwegein's water consumption and water leakage levels are low. However, wastewater treatment can be improved by recovering nutrients. Also, green space and solid-waste production require improvements.

The BCI (Blue City Index) **is 6.7**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **6.7**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	6.1
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	9.9
13	WWT Energy Efficiency	7.0
14	Average Age Sewer	5.4
15	Operation Cost Recovery	8.5
16	Water System Leakages	9.5
17	Stormwater Separation	1.0
18	Green Space	2.5
19	Climate Adaptation	7.0
20	Drinking Water Consumption	10.0
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.0
23	Public Participation	8.1
24	Water Efficiency Measures	7.0
25	Attractiveness	6.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Sandy river bank of the Rhine in the national park de Blauwe Kamer in Betuwe, Netherlands. © Rudmer Zwerver / Shutterstock.com

WATER BASICS

The River Rhine is the principal water source for Nieuwegein, supplied via a water abstraction and treatment plant. Nieuwegein is connected to a series of waterways, the main ones being the Lek River, the Amsterdam Rhine canal and the Merwede canal. The city's water company also operates a water-monitoring station that ensures a continuous water quality monitoring of the Rhine.

Annual average rainfall (mm)	803
Daily average air temperature (°C)	9.3
% of blue and green area	24.0
% of soil sealed	50.2
% flooded by 1-m sea-level rise	100
% flooded by 1-m river-level rise	14.8

DRINKING WATER

Given the essential importance of the Rhine to the Dutch water supply, including Nieuwegein, the entire system is closely monitored, often with online systems that operate 24 hrs a day. Water quality in Nieuwegein is in full compliance with strict Dutch and EU requirements. The Netherlands is one of the few countries where chlorine is used very sparingly, with water quality being protected by water safety plans and comprehensive monitoring.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	2.5
Drinking water consumption (m^3/cap/year)	45.2
Drinking water consumption (litres/cap/day)	126

WASTEWATER

The Nieuwegein wastewater treatment plant uses advanced processes for nitrogen and phosphorus recovery, thereby establishing wastewater as a source of primary materials. In addition, the wastewater also provides an energy source. The carbon from wastewater streams is converted through anaerobic digestion into methane gas, which is then used as an energy source, mostly for combined heat and power plants.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	0.0
Average age of sewer (years)	33
% sewer with separated stormwater and sanitary water	10.0

Autumn trees in Nieuwegein.
© Dennis Jungschlager / Shutterstock.com

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 229%

2036-2065 22%

2066-2095 296%

0 600%

Average % change in population directly affected

2006-2035 255%

2036-2065 42%

2066-2095 340%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea level rise).

UTRECHT

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 0.09 M€

0 300M€

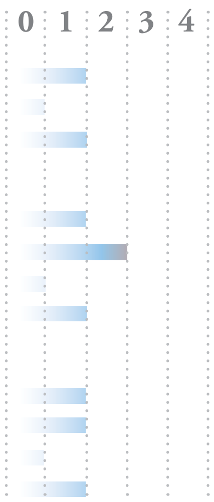
Population directly affected: 5 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

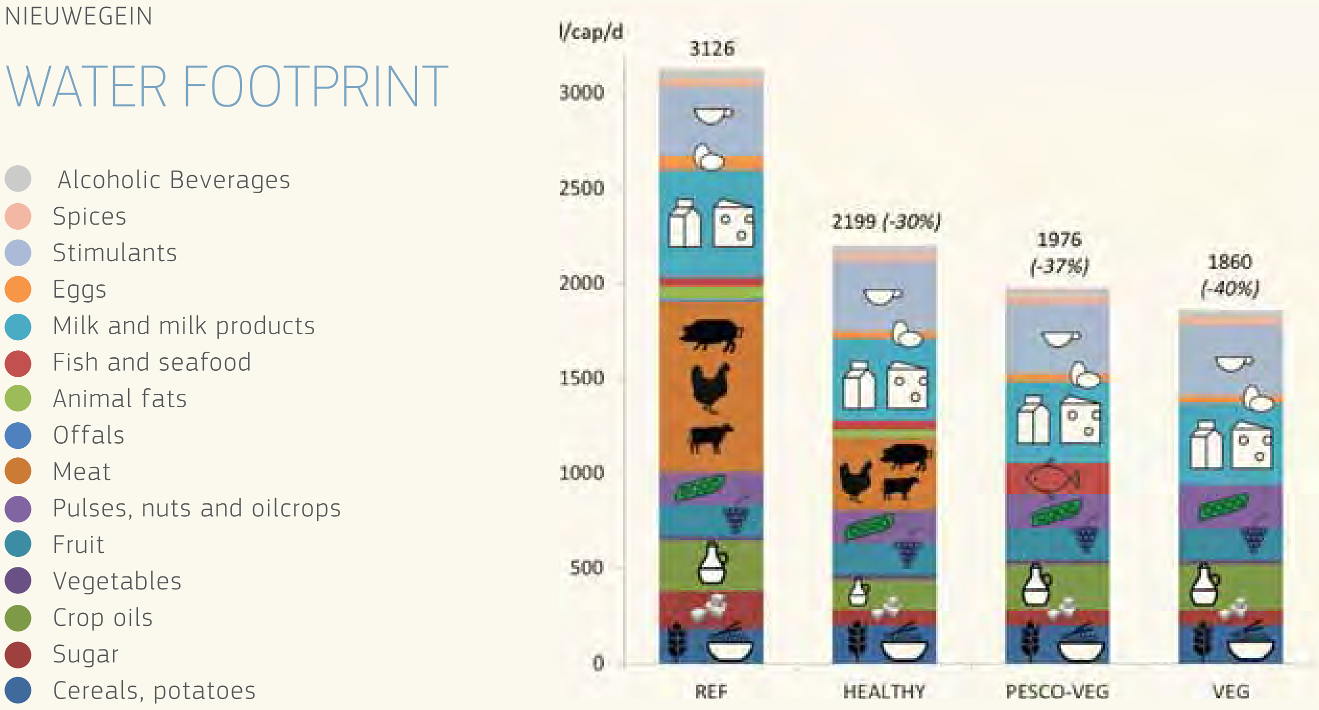
0.9



Within this table, lower numbers are better.

NIEUWEGEIN

WATER FOOTPRINT



This figure shows the water footprint (WF) related to food consumption for Nieuwegein. Four diet scenarios are shown. The current diet of the inhabitants of Nieuwegein leads to a WF of 3 126 l/cap/d, an amount that exceeds the direct water use of the city (45.2 m^3/cap/year which equals 126 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2 199 l/cap/d, so a reduction of 30%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 37% reduction to 1 976 l/cap/d) and a vegetarian diet (a 40% reduction to 1 860 l/cap/d). Nieuwegein's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565, 232–239

Oslo

59°54′45″ N | 10°44′45″ E *Country: Norway, Region: Oslo*

National Flag City Flag Coat of Arms

The Norwegian Opera and Ballet against a background of blue sky and blue waters of the Oslofjord, Oslo, Norway. © Anna Jedynak / Shutterstock.com | Below: Modern buildings in Oslo, Norway. © William Perugini / Shutterstock.com

OSLO

Oslo is the dynamic capital of Norway. It is the second wealthiest metropolitan region in the world, with a per-capita income of over $74 000, and the fastest growing in Europe. The municipality of Oslo has a population of 618 000, and the wider metropolitan area 1 400 000. The two factors of wealth and population are connected. Because the Norwegian and Oslo economies continue to grow despite the recession in the rest of Europe and the OECD countries, the city has a continued attraction for migrant labour.

Oslo is geographically situated at the top of the Oslo Fjord, enclosed by forests and mountains. This location is exceptional for a capital city. Thanks to the Gulf Stream bringing warm waters from the south, Oslo's climate is much milder than its latitude would otherwise suggest.

Resident population (x 1 000)	618
Population density (inhabitants/km²)	1 362
Waste production kg/cap/year	490
% Recycling and composting	40
% Incineration with energy recovery	56
% Landfill	2

ENVIRONMENTAL QUALITY

Oslo, its history, industry and people, are shaped by its proximity to water. The Akerselva River powered numerous workshops that established themselves on its banks in the early 19th century. Today, an important political goal for the city is to promote blue-green infrastructure and to reopen its waterways to bring natural running water back to the urban environment and people's daily lives. Air quality varies seasonally and geographically.

The air quality is good in all areas in summer, but more variable in winter.

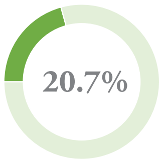
Oslo has an integrated waste management system based on the Waste Management Hierarchy. In 2011, about 240 000 tonnes of household waste were collected. Oslo's vision is to reduce greenhouse gas emissions by 2030 to 50% compared to 1990 levels.

WATER DEMAND & AVAILABILITY

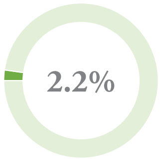
Based on the JRC's LISFLOOD model

W.E.I. stands for Water Exploitation Index

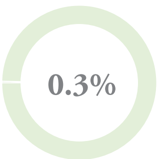
% SOIL WATER STRESS days during year



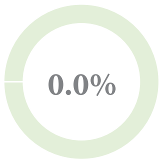
W.E.I. DEMAND



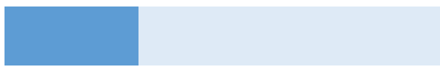
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



OSLO

CITY BLUEPRINT ©

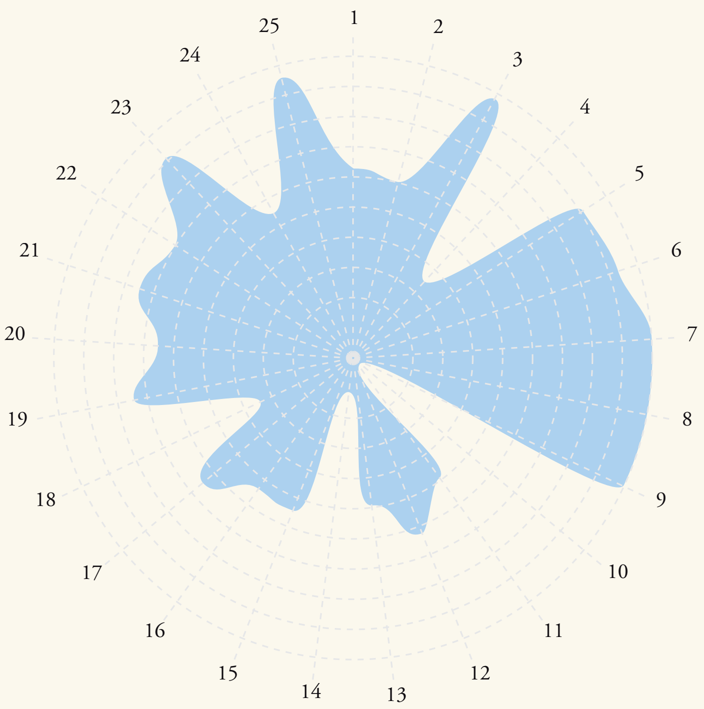
Oslo has an excellent solid waste treatment regime. There is room for improvement regarding the city's wastewater treatment. Aging water infrastructure requires continuous attention.

The BCI (Blue City Index) **is 5.8**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **5.8**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	6.2
2	Tertiary WWT	6.0
3	Groundwater Quality	9.8
4	Solid Waste Collected	3.6
5	Solid Waste Recycled	9.1
6	Solid Waste Energy Recovered	9.3
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	5.0
12	Sewage Sludge Recycling	6.2
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	1.0
15	Operation Cost Recovery	5.4
16	Water System Leakages	5.4
17	Stormwater Separation	6.4
18	Green Space	3.4
19	Climate Adaptation	7.5
20	Drinking Water Consumption	6.4
21	Climate Robust Buildings	7.5
22	Management and Action Plans	7.0
23	Public Participation	9.0
24	Water Efficiency Measures	5.5
25	Attractiveness	9.5

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., 2013. City Blueprints: Baseline Assessments of Sustainable Water Management in 11 Cities of the Future. Water Resources Management, 27, 5191-5206
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Aerial view of Oslo. © Beas777 / Shutterstock.com

WATER BASICS

Oslo city's water resources portfolio consists of forty lakes scattered in the large forest areas around the city, eight major urban watercourses and the Oslo fjord. Rapid population growth in the urban and wider metropolitan area places significant stress on this unique fresh-marine water environment and poses challenges regarding ecosystem and water supply security, and the need for sensitive management of wastewater services.

Annual average rainfall (mm)	760
Daily average air temperature (°C)	6.0
% of blue and green area	26.7
% of soil sealed	28.0
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	44.3

DRINKING WATER

The drinking water supply in Oslo, as for the whole of Norway, is of excellent quality. The main drinking water source is Maridalen Lake, while a back-up source is planned from Langlia Lake.
The Oset water treatment plant supplies 90% of Oslo's population. It is the largest municipal water treatment plant in Scandinavia, with a production capacity of 390 000 m^3/day and the largest in Europe constructed underground.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	22.9
Drinking water consumption (m^3/cap/year)	124.2
Drinking water consumption (litres/cap/day)	345

WASTEWATER

All wastewater from Oslo is treated at Bekkelaget or VEAS plants. Bekkelaget removes organic matter and phosphorous, while VEAS removes organic matter, phosphorous and nitrogen. The new Midgardsormen Project will ensure better handling of stormwater overload. It includes an upgrade to Bekkelaget and a new 2-km tunnel to convey discharges eastwards, away from Oslo's central Bjørvika Bay, to make it more attractive for recreation.

% population connected to at least secondary wastewater treatment	62.0
% population connected to tertiary wastewater treatment	59.7
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	80.0
Average age of sewer (years)	55
% sewer with separated stormwater and sanitary water	64.0

City centre of Oslo.
© Jaroslav Moravcik / Shutterstock.com

NORWAY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 166%

2036-2065 218%

2066-2095 201%

0 400%

Average % change in population directly affected

2006-2035 196%

2036-2065 258%

2066-2095 269%

0 550%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

OSLO

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 4.0 M€

0 300M€

Population directly affected: 33 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

0.9

0 1 2 3 4

Social
Urbanisation Rate
Burden of Disease
Education Rate

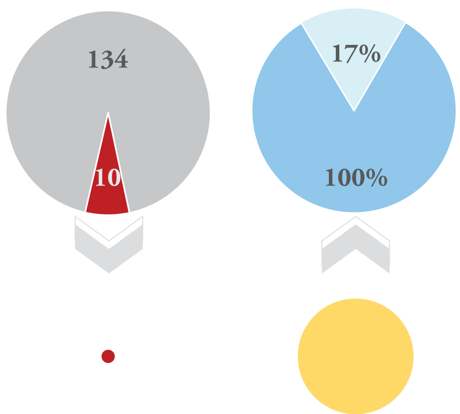
Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate

Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



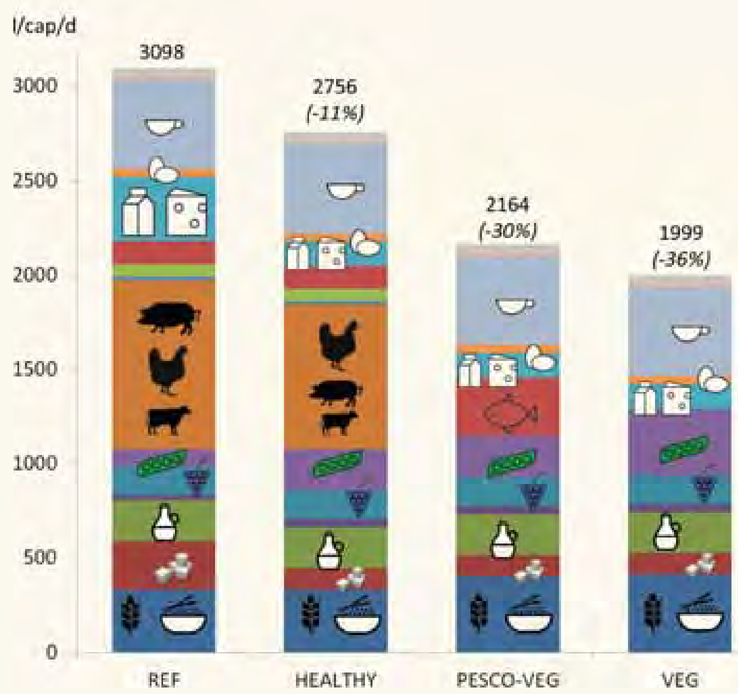
ALERT: 1 WARNING: 0 WATCH: 9

Stress incidents for drought level

OSLO

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Oslo. Four diet scenarios are shown. The current diet of the inhabitants of Oslo leads to a WF of 3 098 l/cap/d, an amount that exceeds the direct water use of the city (124.2 m^3/cap/year which equals 345 l/cap/d) substantially. A healthy diet including meat, as recommended by the Norwegian National Nutrition Council (Nasjonalt råd for ernæring), leads to a WF of 2 756 l/cap/d, so a reduction of 11%. Even greater reductions in the WF are observed for a healthy pesco-vegetarian diet (a 30% reduction to 2 164 l/cap/d) and a vegetarian diet (a 36% reduction to 1 999 l/cap/d). Oslo's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

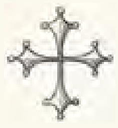
References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

Pisa

43°42'30" N | 10°24'12" E *Country: Italy, Region: Tuscany*


National Flag


City Flag


Coat of Arms


Leaning tower of Pisa, Italy. © Lee Yiu Tung / Shutterstock.com | Below: View of the old city of Pisa from the leaning tower. © DaLiu / Shutterstock.com

PISA

Pisa, in Tuscany, Italy, has a population of some 90 000. Best known for the world-famous Leaning Tower, it is also home to other magnificent tourist and cultural attractions. The city is dominated by the River Arno just before it reaches the Ligurian Sea, on Italy's north-west coast. Pisa is one of the oldest urban agglomerations in Italy, older than Rome. The economy of Pisa and its surroundings is diverse: industrial sectors such as marine, mechanical, chemical and pharmaceutical, tourism, floriculture, local products, wine, oil and services.

Pisa has a Mediterranean climate characterised by mild winters and very warm summers, with an annual average temperature of 14.3°C. Unusually for such a climate, autumn and not winter has the highest levels of precipitation, of which the annual average is 900 mm.

Resident population (x 1,000)	89
Population density (inhabitants/km²)	479

ENVIRONMENTAL QUALITY

The Municipality of Pisa has implemented a Smart City project based on four axes: quality of life, knowledge (R&D, education), accessibility (participation, e-services) and sustainability (environment, energy, mobility, development). Pisa is well known for its cycle paths and pedestrian walkways, thus making the city a very attractive place in which to live.

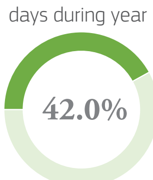
Pisa is strongly committed towards an environmental policy that promotes renewable energy and high-efficiency heating systems. Thus, the renewable energy sector is considered to be of strategic importance for local growth and wealth. As regards waste separation, Pisa is one of the model cities for Italy.

WATER DEMAND & AVAILABILITY

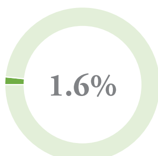
Based on the JRC's LISFLOOD model

W.E.I. stands for Water Exploitation Index

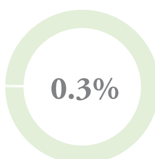
% SOIL WATER STRESS days during year



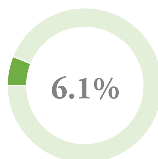
W.E.I. DEMAND



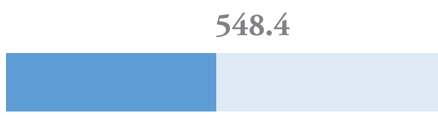
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)




Old town of Pisa with reflection in Arno river, Italy. © Patryk Kosmider / Shutterstock.com

Resident Population and Population Density data: EUROSTAT, 2014

Arno river at night in Pisa, Italy. © waku / Shutterstock.com

WATER BASICS

Pisa, which lies on the Arno alluvial plain 10 km from the coast, was by the sea until the 15th century, after which accumulated silt deposited by the river separated it from the receding shoreline. Pisa is vulnerable to occasional flooding, as experienced during storms in August 2015. In fact, floods on the Arno in the mid-1400s inspired Leonardo da Vinci to pursue pioneering studies on river flow and flood risk.

Annual average rainfall (mm)	900
Daily average air temperature (°C)	14.3

DRINKING WATER

The water distributed to Pisa is of good quality and monitored regularly. It originates from groundwater resources fed by sub-channels of the Serchio River. A variety of wells with depths varying from 5 to 70 metres are the main source of the local water supply. Water was previously supplied via the Medicean Aqueduct built in 1613, but which became unviable due to structural problems, including leaning.

WASTEWATER

Pisa plans an upgrade and enlargement of its principal wastewater treatment plant. The plant is located north of the city, and is integrated into a system of biological treatment of public wastewater at San Jacopo. The process consists of treatment by flocculation and settlement followed by physic-chemical stabilisation. The plant has a maximum capacity of 18 000 tonnes per year.

Horse carriage ride on the streets of Pisa old town.
© Patryk Kosmider / Shutterstock.com

ITALY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 48%

2036-2065 177%

2066-2095 394%

0 600%

Average % change in population directly affected

2006-2035 105%

2036-2065 283%

2066-2095 515%

0 750%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

Ponte di Mezzo bridge and street lamp. Lungarno view.
© StevanZZ / Shutterstock.com

TUSCANY

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 22 M€

0 300M€

Population directly affected: 4924 inh.

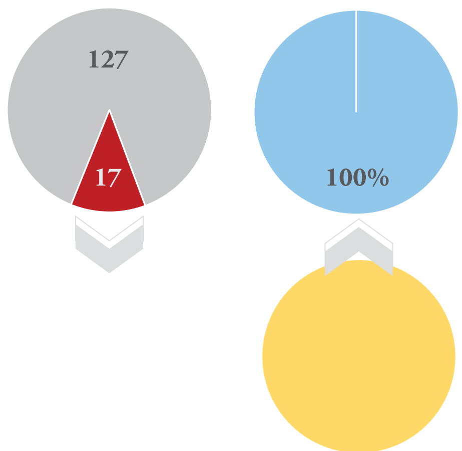
0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

People visit Old Town of Pisa.
© Tupungato / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



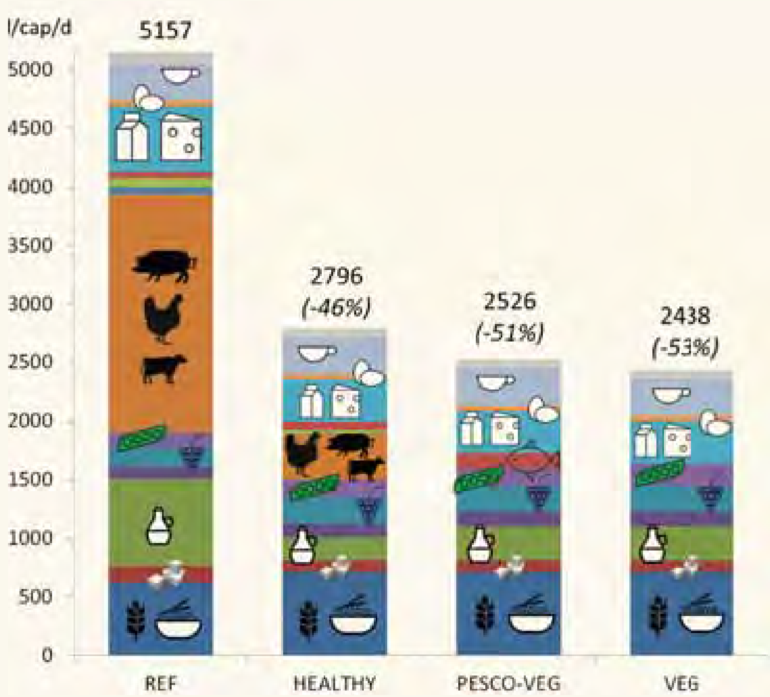
ALERT: 0 WARNING: 0 WATCH: 17

Stress incidents for drought level

PISA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



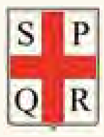
This figure shows the water footprint (WF) related to food consumption for Pisa. Four diet scenarios are shown. The current diet of the inhabitants of Pisa leads to a WF of 5 157 l/cap/d, an amount that exceeds the direct water use of the city (64.8 m³/cap/year which equals 180 l/cap/d) substantially. A healthy diet, as recommended by the Italian National Research Institute on Food and Nutrition (INRAN, Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione; Linee guida per una sana alimentazione italiana), leads to a WF of 2 796 l/cap/d, so a reduction of 46%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 51% reduction to 2 526 l/cap/d) and a vegetarian diet (a 53% reduction to 2 538 l/cap/d). Pisa's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

Reggio Emilia


Country Flag



Coat of Arms

44°41′53″ N | 10°37′52″ E   *Country: Italy, Region: Emilia-Romagna*


Cathedral at Prampolini Square, Reggio Emilia, Italy. © Gianluca Figliola Fantini / Shutterstock.com | Below: "Romolo Valli" Municipal Theater in Reggio Emilia. © Eddy Galeotti / Shutterstock.com

REGGIO EMILIA

Reggio Emilia is in the Po Valley of Northern Italy, about 50 km north-west of Bologna on the old Roman road of Via Emilia, lying between Parma to the west and Modena to the east. With about 170 000 inhabitants, it is the capital city of its province in the eastern part of the Emilia Romagna region. Its character has changed significantly in recent decades, becoming densely built, with a high population growth rate due to immigration. It is in a region of intensive agricultural practices, livestock farming and a number of small industries, many devoted to food production and processing. One of its products is the world renowned Parmigiano-Reggiano cheese. Another is Lambrusco wine.
The climate is temperate continental, with hot summers and a high degree of humidity, with average annual rainfall of 781 mm.

Resident population (x 1 000)	172.5
Population density (inhabitants/km²)	748
Waste production kg/cap/year	540
% Recycling and composting	34
% Incineration with energy recovery	17
% Landfill	49

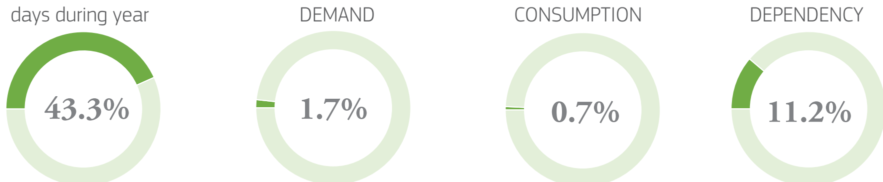
ENVIRONMENTAL QUALITY

Environmental sustainability and care of public spaces are central goal of the city. However, Reggio Emilia is currently facing both environmental and social challenges, including scarcity concerns regarding water and energy. As a result, the city implemented a rigorous water leak reduction programme, and initiatives to promote energy efficiency.
A strong effort is also being made to develop the local transportation system while reducing air pollution and traffic pressure in the city's inner area. Reggio Emilia has an elaborate cycle-path network, and aims to promote cycling as a primary transport means for home-to-school/work commuting trips. It consists of of 12 main radial routes linking the centre to external traffic routes.

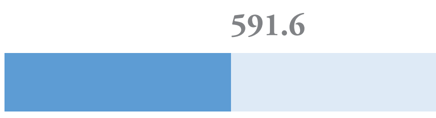
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year | W.E.I. DEMAND | W.E.I. CONSUMPTION | Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



REGGIO EMILIA

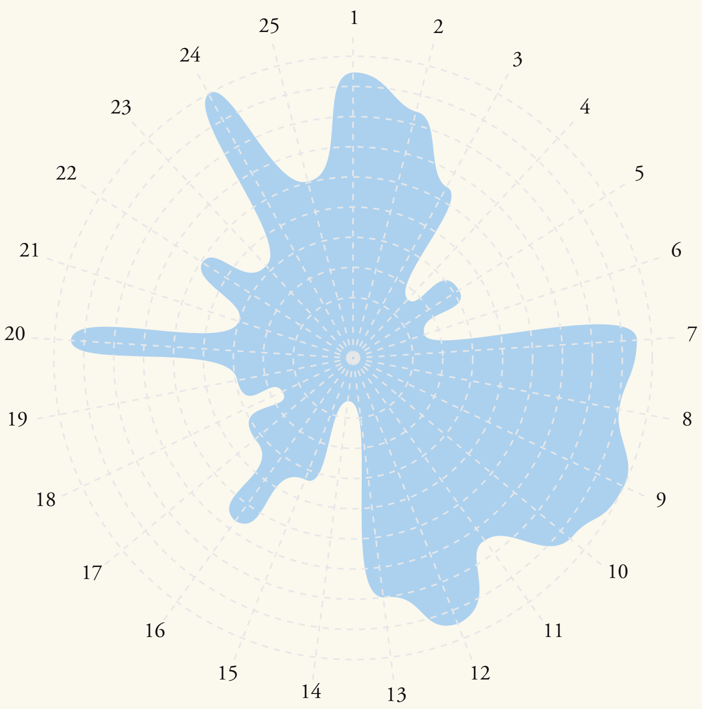
CITY BLUEPRINT ©

The wastewater treatment of Reggio Emilia is of high quality. Nevertheless, solid-waste treatment, incorporation of blue-green infrastructure, water infrastructure management and climate adaptation planning can be improved.

The BCI (Blue City Index) **is 5.8**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).
The Blue City Index is **5.8**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.4
2	Tertiary WWT	8.4
3	Groundwater Quality	6.5
4	Solid Waste Collected	2.7
5	Solid Waste Recycled	4.1
6	Solid Waste Energy Recovered	2.6
7	Access to Drinking Water	9.4
8	Access to Sanitation	9.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	9.4
11	Energy Recovery	7.5
12	Sewage Sludge Recycling	9.4
13	WWT Energy Efficiency	8.0
14	Average Age Sewer	1.6
15	Operation Cost Recovery	4.3
16	Water System Leakages	6.8
17	Stormwater Separation	4.1
18	Green Space	2.7
19	Climate Adaptation	4.0
20	Drinking Water Consumption	9.4
21	Climate Robust Buildings	4.0
22	Management and Action Plans	6.0
23	Public Participation	4.2
24	Water Efficiency Measures	10.0
25	Attractiveness	6.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Panoramic view of Reggio Emilia hills in the north of Italy, with the famous Rossena castle. © Eddy Galeotti / Shutterstock.com

WATER BASICS

Reggio Emilia has an approved policy to bring the private water supplier, Iren Emilia, back to public ownership (re-municipalisation). Water supply originates from groundwater via the Quercioli wellfield in the alluvial fan of the Enza River (a tributary of the Po), located in the hills south-west of the city.

Annual average rainfall (mm)	781
Daily average air temperature (°C)	11.0
% of blue and green area	24.7
% of soil sealed	41.1
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	25.1

DRINKING WATER

Drinking water originates 100% from groundwater in the alluvial plain, and serves 93.8% of the population. Average water consumption is 58.9 m³ per person per year. Drinking water quality is excellent. The water mains length is 575 km and the average age is 50-60 years. The number of water mains failures is relatively high (117.5 per 100 km) and the water losses, despite advanced efforts to reduce them, are about 16%.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	93.8
% leakage rate water distribution system	16.0
Drinking water consumption (m³/cap/year)	58.4
Drinking water consumption (litres/cap/day)	162

WASTEWATER

Reggio Emilia has a system of both combined and separated sanitary and stormwater sewers, with a separation rate of 40%. The average age of the network is about 52 years, reflected in a sewer blockage rate of 56.7 per 100 km. Because of the high energy costs of the wastewater system (€1 million per year) measures have been taken to recover energy from wastewater.

% population connected to at least secondary wastewater treatment	94.0
% population connected to tertiary wastewater treatment	84.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	80.0
Average age of sewer (years)	52
% sewer with separated stormwater and sanitary water	40.6

View trough ,Gualtieri.
© Gianluca Figliola Fantini / Shutterstock.com

ITALY

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	48%
2036-2065	177%
2066-2095	394%
0	600%

Average % change in population directly affected

2006-2035	105%
2036-2065	283%
2066-2095	515%
0	750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

EMILIA-ROMAGNA

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 213 M€

0 — 300M€

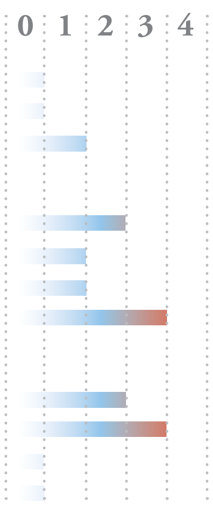
Population directly affected: 2000 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

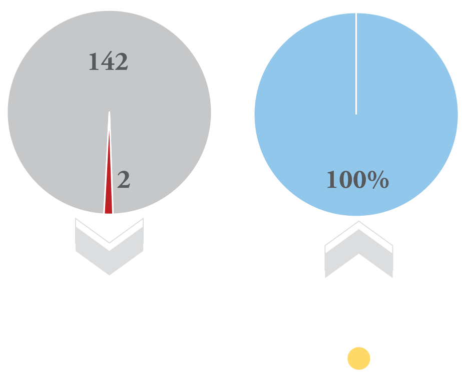
1.3



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



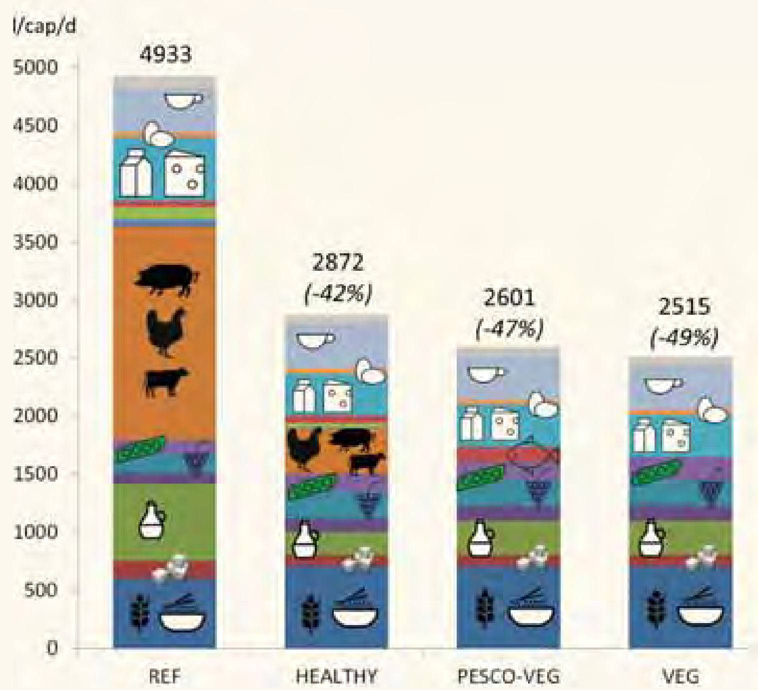
ALERT: 0 WARNING: 0 WATCH: 2

Stress incidents for drought level

REGGIO EMILIA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Reggio Emilia. Four diet scenarios are shown. The current diet of the inhabitants of Reggio Emilia leads to a WF of 4 933 l/cap/d, an amount that exceeds the direct water use of the city (58.4 m³/cap/year which equals 162 l/cap/d) substantially. A healthy diet, as recommended by the Italian National Research Institute on Food and Nutrition (INRAN, Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione; Linee guida per una sana alimentazione italiana), leads to a WF of 2 872 l/cap/d, so a reduction of 42%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 47% reduction to 2601 l/cap/d) and a vegetarian diet (a 49% reduction to 2 515 l/cap/d). Reggio Emilia's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

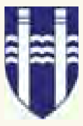
l/cap/d = litres / cap / day

References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

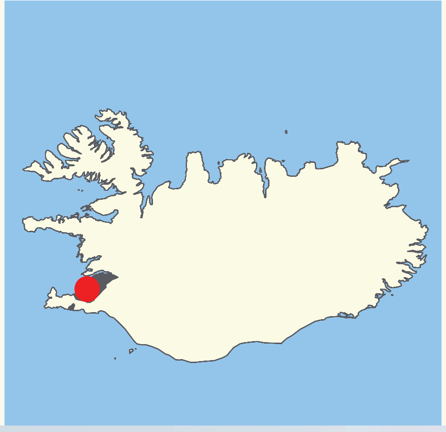
Reykjavik

64°08'07" N | 21°53'43" W *Country: Norway, Region: Iceland*

National Flag



Coat of Arms



Aerial view of Reykjavik, Iceland in winter with harbor and skyline mountains beyond the city. Seen from the observation desk in Perlan. © Wojtek Chmielewski / Shutterstock.com

Below: Eruption of Strokkur geyser in Iceland. © ZinaidaSopina / Shutterstock.com

REYKJAVIK

Iceland has a population of 320 000, of which two thirds live in the capital Reykjavik and its metropolitan area. With a population of 120 000, Reykjavik is the world's most northerly capital, just 270 km south of the Arctic Circle, and Europe's most westerly. Located in southwestern Iceland, on a peninsula with striking panoramic views of the mountains and the Atlantic Ocean, Reykjavik is the centre of government, administration and economic activity. Climate is subarctic maritime, with cool temperatures throughout the year moderated by the warming influence of the North Atlantic Current, although with weather that is unpredictable and highly changeable. The average winter temperature is 0°C and summer 12°C, but can reach 25°C on the warmest days. Average precipitation is 810 mm/y.

Resident population (x 1 000)	119
Population density (inhabitants/km²)	434
Waste production kg/cap/year	550
% Recycling and composting	16
% Incineration with energy recovery	11
% Landfill	73

ENVIRONMENTAL QUALITY

Reykjavik has the world's largest geothermal heating system - made possible by the country's unusual geology - and is at the forefront of promoting alternative fuel and electric cars. Many of Iceland's fruit and vegetables are grown in geothermally heated greenhouses illuminated with hydro-electricity. Reykjavik's tap water is naturally highly pure and untainted by chemicals and minerals, with no requirement for treatment.

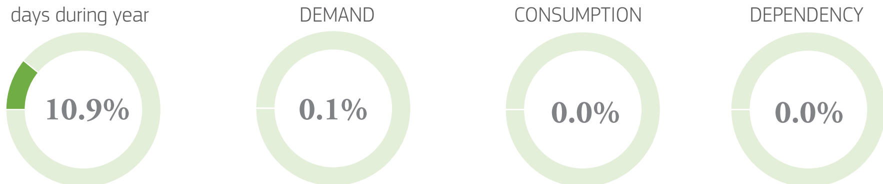
All buildings in Reykjavik (and in most of Iceland) are heated with geothermal water. In 2009, the Council of Reykjavík set a policy to decrease the emissions of greenhouse gasses by 35% by 2020, and by 73% by 2050, compared to emissions in 2007.

WATER DEMAND & AVAILABILITY

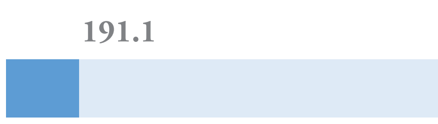
Based on the JRC's LISFLOOD model

W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year | W.E.I. DEMAND | W.E.I. CONSUMPTION | Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



REYKJAVIK

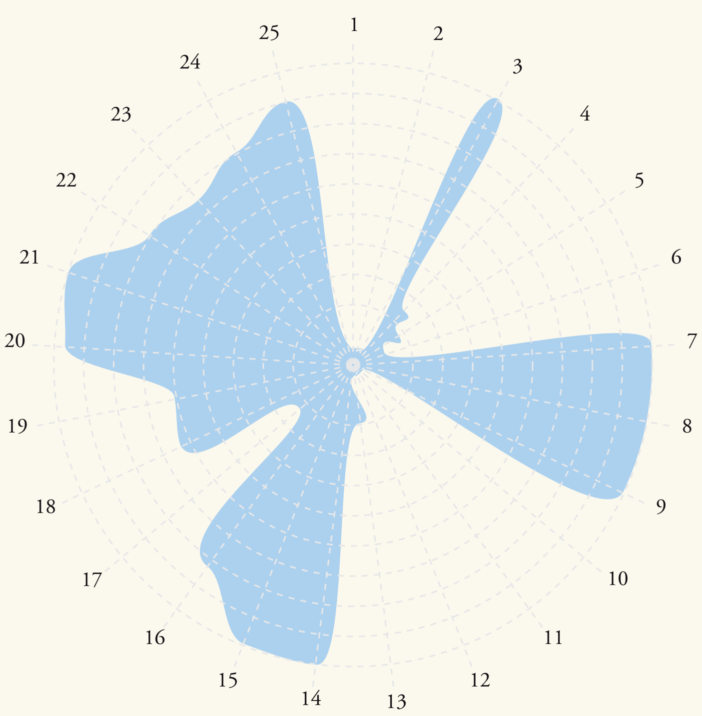
CITY BLUEPRINT ©

Reykjavik has a low level of drinking water consumption and has elaborated climate change adaptation policy. However, wastewater treatment and solid waste treatment in the city are major challenges.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **3.9**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	0.2
2	Tertiary WWT	0.1
3	Groundwater Quality	10
4	Solid Waste Collected	2.5
5	Solid Waste Recycled	1.8
6	Solid Waste Energy Recovered	1.3
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	9.9
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	2.0
14	Average Age Sewer	10.0
15	Operation Cost Recovery	10.0
16	Water System Leakages	8.2
17	Stormwater Separation	2.2
18	Green Space	6.3
19	Climate Adaptation	6.0
20	Drinking Water Consumption	9.6
21	Climate Robust Buildings	10.0
22	Management and Action Plans	8.0
23	Public Participation	7.6
24	Water Efficiency Measures	8.0
25	Attractiveness	9.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Panorama of the skyline cityscape of Reykjavik, reflected in lake Tjornin during winter. © Dennis van de Water / Shutterstock.com

WATER BASICS

Public water supply is 100% from groundwater, from wellfields south-east of Reykjavik in a volcanic rock aquifer. There are approximately 20 boreholes, up to 130 metres deep across three main wellfields with strict protection controls. There is a general abundance of groundwater in the Reykjavik area. Iceland has the highest renewable water resources per capita in the world, with more than 500 000 m³/pers/yr.

Annual average rainfall (mm)	810
Daily average air temperature (°C)	4.0
% of blue and green area	36.0
% of soil sealed	42.0
% flooded by 1-m sea-level rise	21-40%
% flooded by 1-m river-level rise	21-40%

Northern lights above Reykjavik Iceland.
© Strahil Dimitrov / Shutterstock.com

DRINKING WATER

Under Icelandic law, drinking water is considered food and is therefore managed in accordance with strict food safety controls. Tap water has the quality of pure spring water, without any treatment or additives such as chlorine, and is of naturally very high quality without traces of contaminants or heavy metals. It is protected by strict protection zones, comprehensive monitoring and quality control measures.

% of drinking water samples complying with drinking water regulation	99.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	9.0
Drinking water consumption (m³/cap/year)	54.0
Drinking water consumption (litres/cap/day)	150

Blue lagoon with people in Iceland.
© Rui Serra Maia / Shutterstock.com

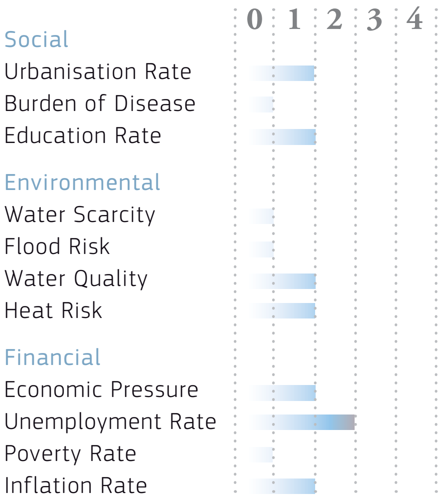
WASTEWATER

Reykjavik's wastewater system, connected to 99.5% of the population, applies less comprehensive treatment than the European norm, with discharge far out to sea on the basis that dilution and dispersion protects against negative impacts, confirmed by studies and monitoring. Improvements have ensured that the volume of wastewater discharge to sea has fallen significantly in recent years, with ongoing upgrading foreseen.

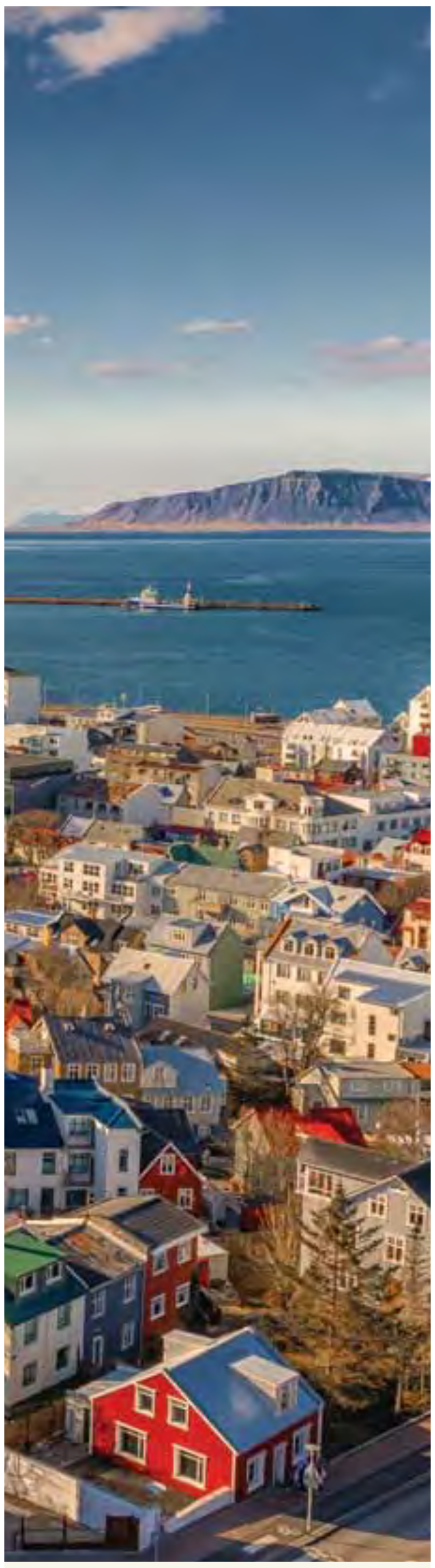
% population connected to at least secondary wastewater treatment	2.0
% population connected to tertiary wastewater treatment	1.0
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	0.0
Average age of sewer (years)	10
% sewer with separated stormwater and sanitary water	22.0

TRENDS & PRESSURES

0.7



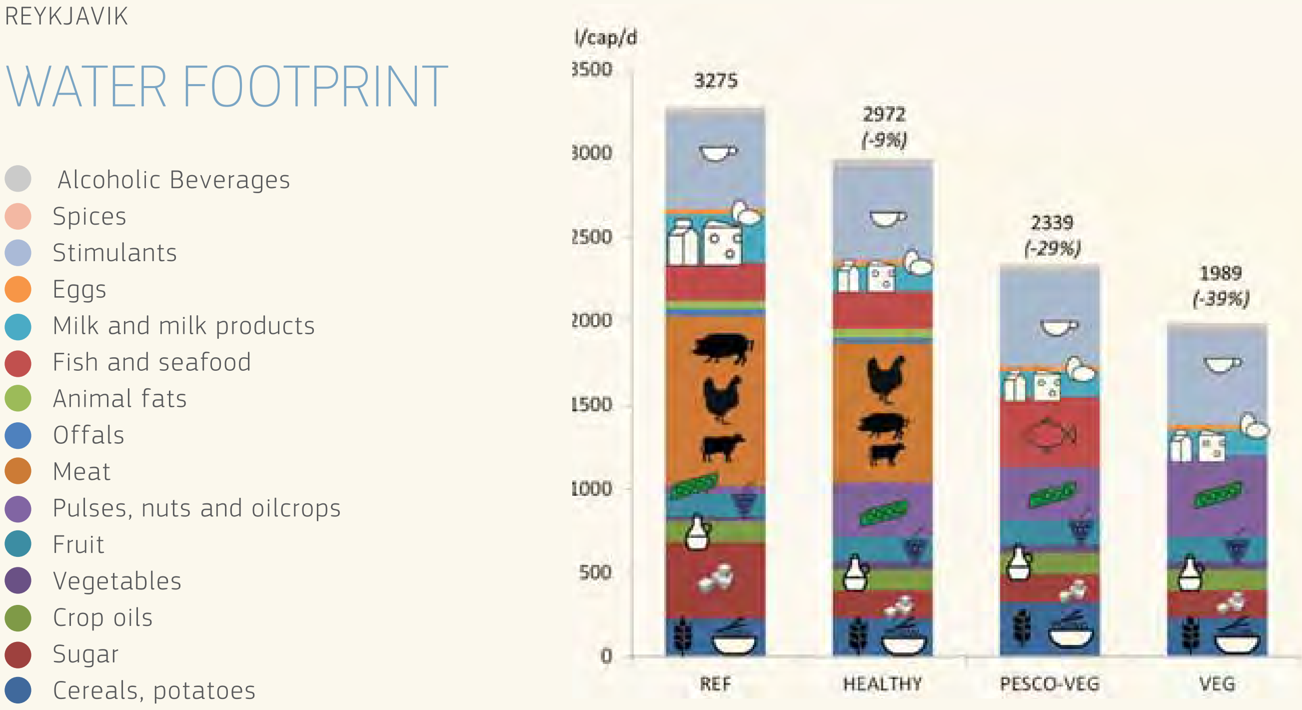
Within this table, lower numbers are better.



Reykjavik from above. © SvedOliver / Shutterstock.com

REYKJAVIK

WATER FOOTPRINT



This figure shows the water footprint (WF) related to food consumption for Reykjavik. Four diet scenarios are shown. The current diet of the inhabitants of Reykjavik leads to a WF of 3 275 l/cap/d, an amount that exceeds the direct water use of the city (54.0 m3/cap/year which equals 150 l/cap/d) substantially. A healthy diet including meat, as recommended by the Icelandic Directorate of Health (Embætti landlæknis), leads to a WF of 2 972 l/cap/d, so a reduction of 9%. Even greater reductions in the WF are observed for a healthy pesco-vegetarian diet (a 29% reduction to 2 339 l/cap/d) and a healthy vegetarian diet (a 39% reduction to 1 989 l/cap/d). Reykjavik's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

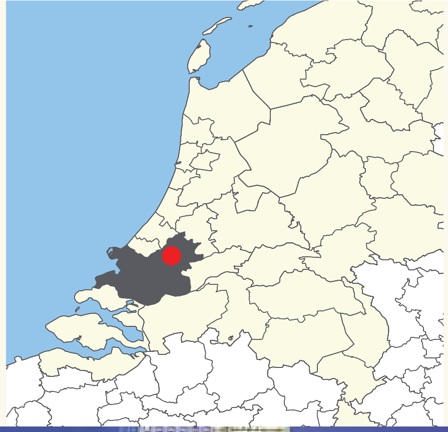
Rotterdam

51°55′20″ N | 4°28′45″ E *Country: The Netherlands, Region: South Holland*


National Flag


City Flag


Coat of Arms




Rotterdam skyline with Erasmus bridge at twilight as seen from the Euromast tower, The Netherlands. © mihaiulia / Shutterstock.com | Below: Cube houses designed by Piet Blom in Rotterdam, Netherlands. © vichie81 / Shutterstock.com

ROTTERDAM

With about 600 000 residents, Rotterdam is the second largest city in the Netherlands, founded in 1270 and granted city rights in 1340. The Port of Rotterdam is the largest in Europe and fifth largest in the world. The port stretches 40 km from the city to the North Sea, along the reclaimed land of the Maasvlakte I and Maasvlakte II port-expansion projects. Located geographically within the Rhine–Meuse/Maas–Scheldt river delta, the city has always been one of the main centres of the shipping industry in the Netherlands, forming, together with Eindhoven and Amsterdam, a key foundation of the Dutch economy.
Rotterdam experiences a temperate oceanic climate similar to most of the Netherlands, but slightly milder than locations further from the coast.

Resident population (x 1 000)	618
Population density (inhabitants/km²)	1 900
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

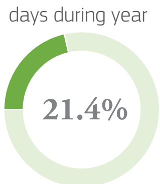
ENVIRONMENTAL QUALITY

Through the Rotterdam Climate Initiative, the city aims to reduce CO_2 emissions in the international port by 50%, aiming to become 'climate proof' by 2025.
There are a number of projects underway to achieve this. Rotterdam features solar cells embedded in the glass of what is believed to be Europe's biggest solar station roof. Excess heat from the port's industries is transported as steam by pipeline to heat a million homes in the city. And, to demonstrate how clean the water is, the WWF wildlife NGO recently reintroduced sturgeon into the Meuse river after 50 years of absence due to pollution. The city council even offers subsidies to residents to grow their own "green roofs".

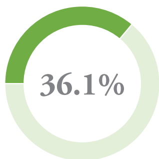
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

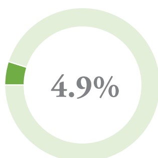
% SOIL WATER STRESS days during year



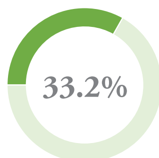
W.E.I. DEMAND



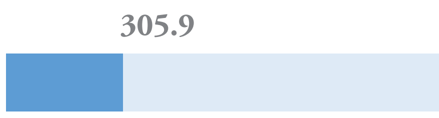
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



ROTTERDAM

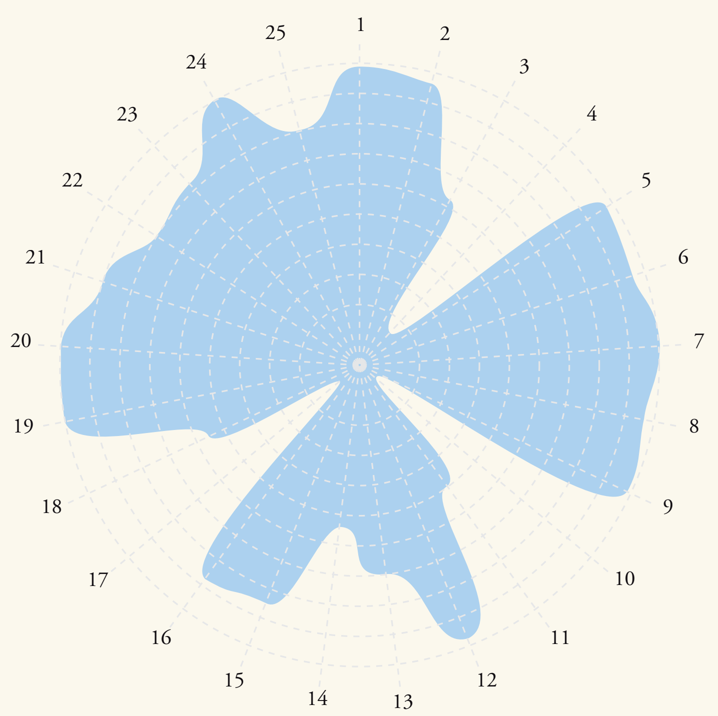
CITY BLUEPRINT ©

Rotterdam is a frontrunner with respect to climate adaptation policy and action. Yet, the city's solid-waste production, stormwater separation and the recovery of nutrients from wastewater can be improved.

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **6.6**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	6.1
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.7
9	Drinking Water Quality	9.9
10	Nutrient Recovery	0.0
11	Energy Recovery	5.0
12	Sewage Sludge Recycling	9.9
13	WWT Energy Efficiency	7.0
14	Average Age Sewer	5.4
15	Operation Cost Recovery	8.5
16	Water System Leakages	8.8
17	Stormwater Separation	0.5
18	Green Space	5.5
19	Climate Adaptation	10.0
20	Drinking Water Consumption	10.0
21	Climate Robust Buildings	9.0
22	Management and Action Plans	8.0
23	Public Participation	8.1
24	Water Efficiency Measures	10.0
25	Attractiveness	8.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Van Leeuwen C.J., Frijns J., van Wezel A., van de Ven F.H.M., 2012. City Blueprints: 24 indicators to assess the sustainability of the urban water cycle. Water Resources Management, 26, 2177–2197
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Large container vessel in Port of Rotterdam. © Beketoff Photography / Shutterstock.com

WATER BASICS

Rotterdam is in a challenging location at zero elevation on a delta, close to the sea. This close proximity to water, however, is barely perceptible in many areas. To cope with this challenge and the projected impacts of climate change, urban water managers have developed a new water management strategy that combines the renewal of water infrastructure with neighbourhood revitalisation projects.

Annual average rainfall (mm)	820
Daily average air temperature (°C)	10.0
% of blue and green area	33.6
% of soil sealed	44.6
% flooded by 1-m sea-level rise	99.3
% flooded by 1-m river-level rise	23.1

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 229%

2036-2065 22%

2066-2095 296%

0 600%

Average % change in population directly affected

2006-2035 255%

2036-2065 42%

2066-2095 340%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not included the effect of flash floods, coastal floods or sea-level rise).

DRINKING WATER

Rotterdam's drinking water is supplied exclusively by Evides Waterbedrijf, a water company serving 2.5 million customers across the Netherlands. Drinking water is sourced 80% from the Meuse/Maas river, 16% from ground water and 4% from dunes. It is supplied at high quality and is strictly controlled, with quality data made easily accessible online.

% of drinking water samples complying with drinking water regulation	99.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	6.0
Drinking water consumption (m^3/cap/year)	45.2
Drinking water consumption (litres/cap/day)	126

SOUTH HOLLAND

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 255 M€

0 300M€

Population directly affected: 19028 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

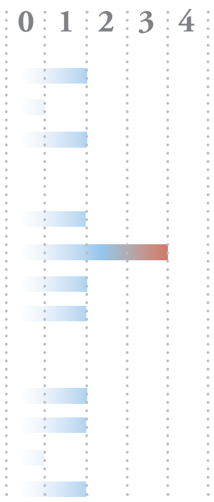
WASTEWATER

Wastewater is managed by Waterboard Hollandse Delta (Water HD), which also manages waterways and protects South Holland from flooding. Wastewater management capacity is 620 000 PE (population equivalent). Nitrogen is recovered using the ANAMMOX® process, removing 95% of ammonium and 85% of nitrogen. Efficiencies also reduce electricity demand, carbon footprint, sludge production and operational costs.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	50.0
Average age of sewer (years)	33
% sewer with separated stormwater and sanitary water	5.0

TRENDS & PRESSURES

1.0

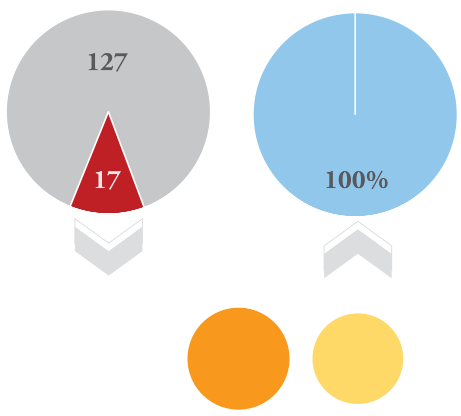


Within this table, lower numbers are better.

Oude Haven oldest part of Rotterdam harbour.
© gnoparus / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



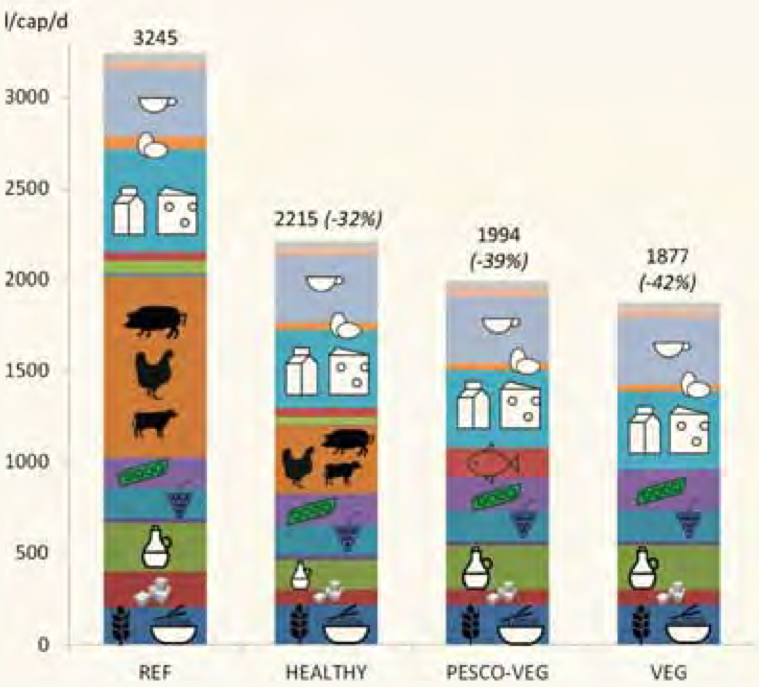
ALERT: 0 WARNING: 9 WATCH: 8

Stress incidents for drought level

ROTTERDAM

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Rotterdam. Four diet scenarios are shown. The current diet of the inhabitants of Rotterdam leads to a WF of 3 245 l/cap/d, an amount that exceeds the direct water use of the city (45.2 m^3/cap/year which equals 126 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2215 l/cap/d, so a reduction of 32%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 39% reduction to 1 994 l/cap/d) and a vegetarian diet (a 42% reduction to 1 877 l/cap/d). Rotterdam's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

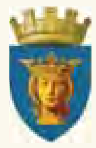
References:
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565, 232–239

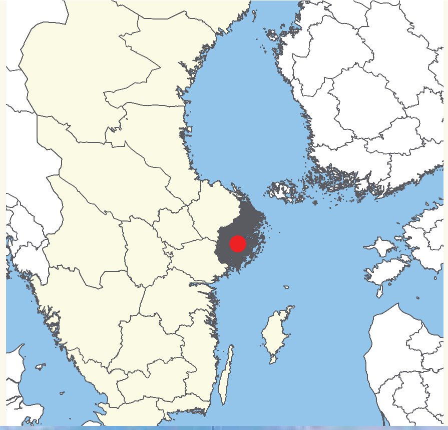
Stockholm

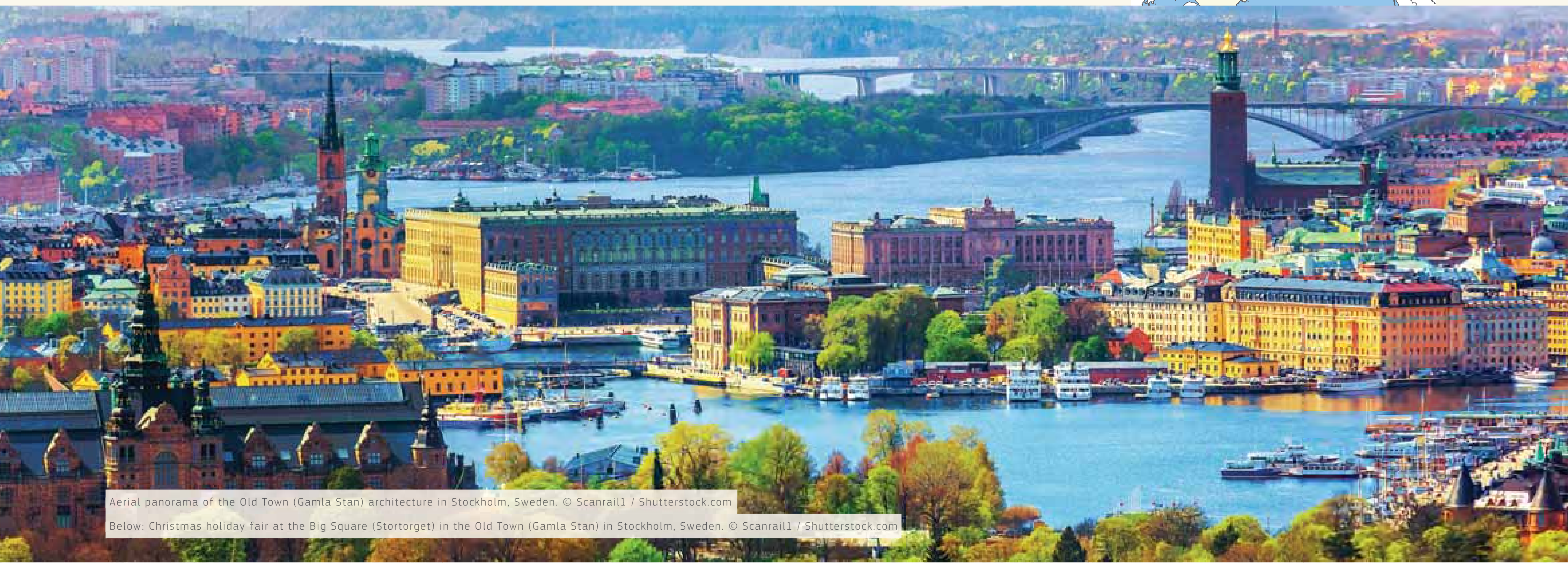
59°19′57″ N | 18°03′53″ E *Country: Sweden, Region: Stockholm*


National Flag


City Flag


Coat of Arms





Aerial panorama of the Old Town (Gamla Stan) architecture in Stockholm, Sweden. © Scanrail1 / Shutterstock.com

Below: Christmas holiday fair at the Big Square (Stortorget) in the Old Town (Gamla Stan) in Stockholm, Sweden. © Scanrail1 / Shutterstock.com

STOCKHOLM

Sweden's capital city is spreads over 14 islands in Lake Mälaren and looks out proudly to the Baltic Sea to the east. The grand public buildings, palaces, rich cultural tradition and museums beautifully reflect the city's 700-year history. Because of its geographic location, Stockholm has four intensely distinct seasons, making it possible to swim in the sea during the summer and ski in the winter. Stockholm combines great expanses of water and greenery with a mixture of historic medieval buildings and contemporary architecture. Stockholm is growing quickly. The city's population is currently 910 000, but is expected to increase to one million by 2020. This puts heavy demands on ambitious and systematic efforts to maintain an attractive and sustainable urban environment.

Resident population (x 1 000)	912
Population density (inhabitants/km²)	4 874
Waste production kg/cap/year	460
% Recycling and composting	47
% Incineration with energy recovery	51
% Landfill	1

ENVIRONMENTAL QUALITY

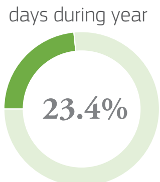
Stockholm was the first city to be awarded the status of European Green Capital in 2010. The city has an integrated administrative system that guarantees their environmental aspects are considered in budgets, operational planning, reporting and monitoring. It has cut CO_2 emissions by 25% per inhabitant since 1990, and has the objective of being fossil-fuel-free by 2050.

Another challenge Stockholm shares with other cities is to design transport solutions with a minimal or reduced impact on the environment. Stockholm has a century-long tradition of waste incineration and waste-to-energy management. Twenty-seven percent of the waste produced by Stockholm citizens is recycled as material or biogas.

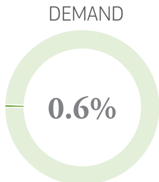
WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index

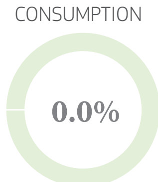
% SOIL WATER STRESS days during year



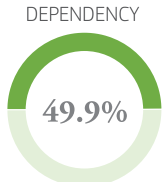
W.E.I. DEMAND



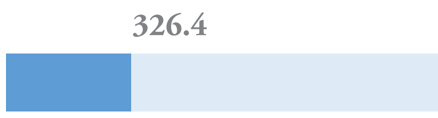
W.E.I. CONSUMPTION



Water DEPENDENCY



Evapotranspiration difference (**mm/y**)



STOCKHOLM

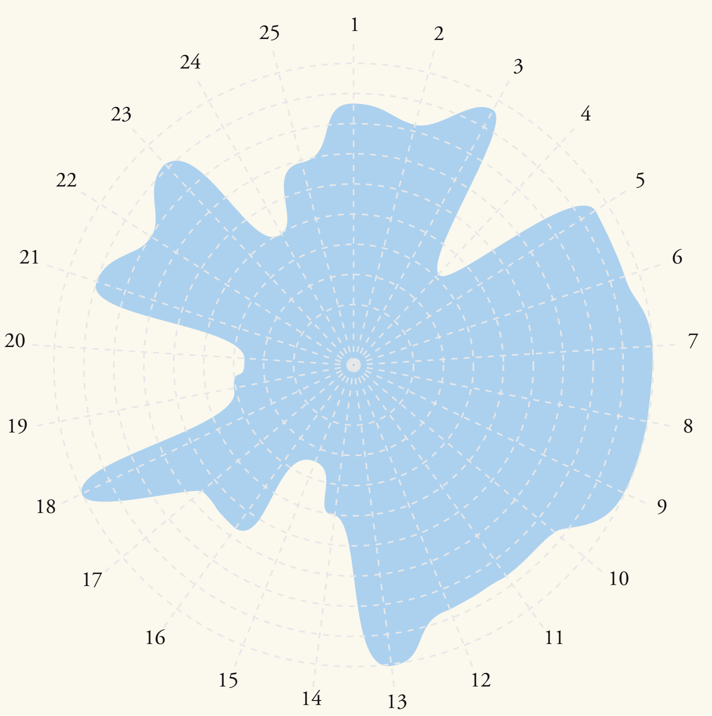
CITY BLUEPRINT ©

Stockholm excels in many aspects of water management, such as wastewater treatment, solid-waste treatment and the incorporation of blue-green areas. However, the city's water consumption is rather high.

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **7.3**

derivative reproduction from original CITY BLUEPRINT (TM)



Nr.	Indicator	Score
1	Secondary WWT	8.7
2	Tertiary WWT	8.3
3	Groundwater Quality	9.8
4	Solid Waste Collected	4.1
5	Solid Waste Recycled	9.6
6	Solid Waste Energy Recovered	9.6
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	8.7
11	Energy Recovery	8.7
12	Sewage Sludge Recycling	8.7
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	5.0
15	Operation Cost Recovery	3.3
16	Water System Leakages	6.6
17	Stormwater Separation	6.5
18	Green Space	10.0
19	Climate Adaptation	4.0
20	Drinking Water Consumption	3.6
21	Climate Robust Buildings	9.0
22	Management and Action Plans	8.0
23	Public Participation	9.2
24	Water Efficiency Measures	5.0
25	Attractiveness	6.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Stortorget place in Gamla stan, Stockholm. © Adisa / Shutterstock.com

WATER BASICS

Lake Mälaren is the source of drinking water, and Lake Bornsjön serves a reserve supply source. Norsborg waterworks produces 60% of treated drinking water. It was built in 1903, at which time it pumped water only from Lake Bornsjön. In 1923, Lake Mälaren became the main water supply source. The other 40% of Stockholm's water is treated in the Lovö waterworks, built in 1933 in the Drottningholm area.

Annual average rainfall (mm)	539
Daily average air temperature (°C)	6.0
% of blue and green area	57.9
% of soil sealed	29.4
% flooded by 1-m sea-level rise	0.6
% flooded by 1-m river-level rise	15.0

DRINKING WATER

Stockholm's famously clean water is consumed at a rate of 200 l/cap/day for the usual range of domestic uses. The high quality is verified by a comprehensive sampling and testing programme. There are more than 2 200 kilometres of water supply pipes in Stockholm and Huddinge, a neighbouring municipality. Each day, 360 000 m³ of drinking water are treated and distributed to 1 million people.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	17.0
Drinking water consumption (m^3/cap/year)	186.5
Drinking water consumption (litres/cap/day)	518

WASTEWATER

All Stockholm homes are connected to the wastewater collection system with two treatment plants, Henriksdal and Bromma, serving a total of 1 million people. Each day, 355 000 m³ of wastewater are treated and discharged at high quality, into the Stockholm archipelago, part of the Baltic Sea. Treatment includes removal of 70% of nitrogen and 98% phosphorous.

% population connected to at least secondary wastewater treatment	87.0
% population connected to tertiary wastewater treatment	83.0
% wastewater that is treated with nutrient-recovering techniques	100
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	35
% sewer with separated stormwater and sanitary water	65.0

Evening at stockholm.
© b-hide the scene / Shutterstock.com

SWEDEN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	37%
2036-2065	25%
2066-2095	90%
0	600%

Average % change in population directly affected

2006-2035	31%
2036-2065	12%
2066-2095	68%
0	750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not included the effect of flash floods, coastal floods or sea-level rise).

STOCKHOLM

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 0.88 M€

0 — 300M€

Population directly affected: 28 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

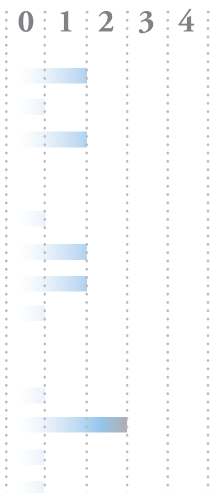
TRENDS & PRESSURES

0.6

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

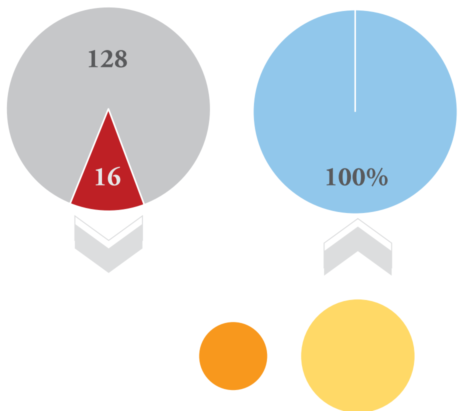
Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



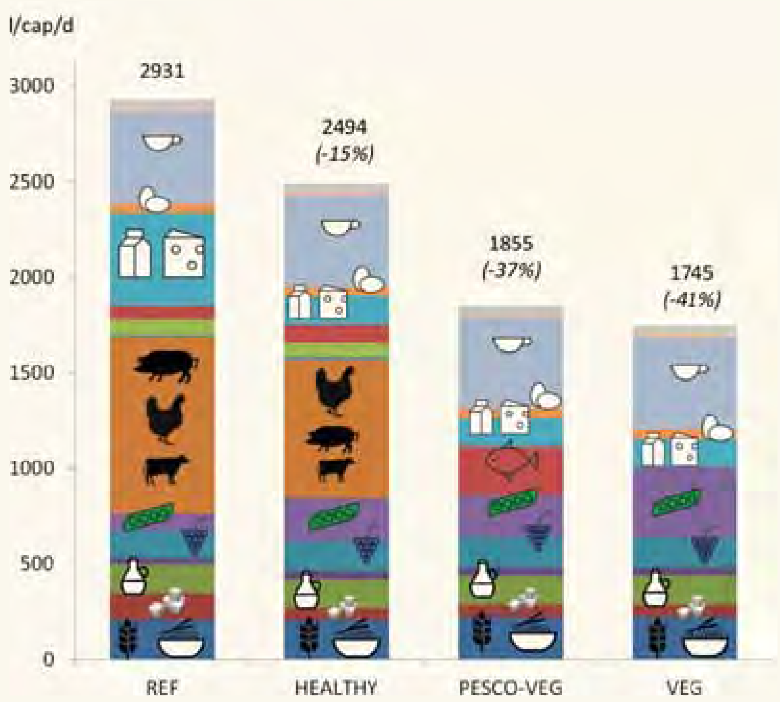
ALERT: 0 WARNING: 6 WATCH: 10

Stress incidents for drought level

STOCKHOLM

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Stockholm. Four diet scenarios are shown. The current diet of the inhabitants of Stockholm leads to a WF of 2 931 l/cap/d, an amount that exceeds the direct water use of the city (186.5 m³/cap/year which equals 518 l/cap/d) substantially. A healthy diet, as recommended by the Swedish National Food Agency (Livsmedelsverket), leads to a WF of 2 494 l/cap/d, so a reduction of 15%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 37% reduction to 1 855 l/cap/d) and a vegetarian diet (a 41% reduction to 1 745 l/cap/d). Stockholm's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

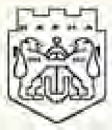
References:
Vanham D., Gawlik B.M., Bidoglio G., 2017. Food consumption and related water resources in Nordic cities. Ecological Indicators, 74, 119–129

Varna

43° 12' 50.58'' N | 27° 54' 53.0388'' E   *Country: Bulgaria, Region: Limburg*


National Flag


City Flag


Coat of Arms


Aerial view of The Cathedral of the Assumption in Varna © Valentin Valkov / Shutterstock.com | Below: Citizens walk in the Sea Port of Varna in a bright sunny day. © ThunderWaffle / Shutterstock.com

VARNA

Varna is the third largest city in Bulgaria, with an area of 205 km². The town was established in the 6th century BC under the name of Odessos. Its situation on the northern shore of the Black Sea, along with its richness in natural resources, make it one of the most famous resorts in Europe, and the largest in the Black Sea region. With its modern port, railway connection and international airport providing connections to 35 states and more than 100 world cities, Varna is one of the largest transport centres in Bulgaria.

The average January temperature in Varna is 1.7°C, the average July temperature is 22.8°C, and the average annual temperature is 12.0°C, which makes it very appropriate for holiday sea tourism during the warm months of the year.

ENVIRONMENTAL QUALITY

The rise of mass tourism in the past decade had a profound impact on the transformation of Varna, as well as on its environmental quality. Thus, the Varna Bay coastal area is one of the hotspots along the Bulgarian Black Sea coast, in that it faces multiple environmental pressures. Impacted by industrial and urban discharges, the ecological state of Varna Bay's ecosystem suffered serious deterioration. Through the cascade system Varna lake-Varna Bay, the industrial wastewaters bring excessive nutrients into the Bay. Since late 1990s, the internationa-lly recognised resorts situated along the coast of Varna region represent another key source of nutrient inputs to the system through the coastal current, due to the expansion of the tourist industry in the area.

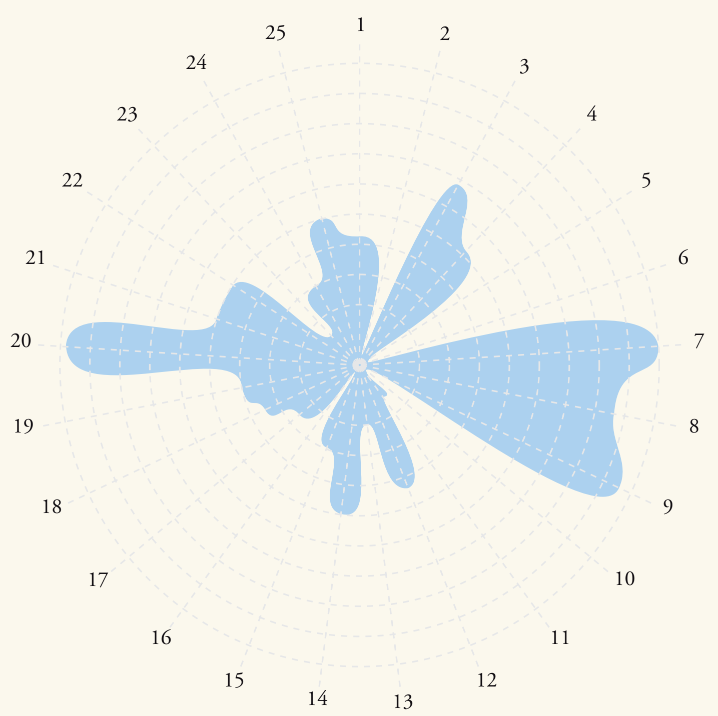
Resident population (x 1 000)	336
Population density (inhabitants/km²)	2 184
Waste production kg/cap/year	405
% Recycling and composting	2
% Incineration with energy recovery	0
% Landfill	98

VARNA

CITY BLUEPRINT ©

Varna's drinking water conservation is excellent. However, the city faces many management challenges, such as improving its wastewater treatment and reducing its climate vulnerability.

The BCI (Blue City Index) is 2.9



The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **2.9**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	4.3
2	Tertiary WWT	0.1
3	Groundwater Quality	6.9
4	Solid Waste Collected	5.1
5	Solid Waste Recycled	0.2
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	8.6
9	Drinking Water Quality	9.5
10	Nutrient Recovery	0.0
11	Energy Recovery	1.3
12	Sewage Sludge Recycling	4.3
13	WWT Energy Efficiency	2.0
14	Average Age Sewer	5.0
15	Operation Cost Recovery	3.0
16	Water System Leakages	0.0
17	Stormwater Separation	2.6
18	Green Space	3.5
19	Climate Adaptation	4.0
20	Drinking Water Consumption	9.9
21	Climate Robust Buildings	5.0
22	Management and Action Plans	5.0
23	Public Participation	1.5
24	Water Efficiency Measures	3.0
25	Attractiveness	5.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Golden Sands Beach ,summer attraction and resort at the Black Sea in Varna, Bulgaria. View from Glarus Hotel. © ELEPHOTOS / Shutterstock.com

WATER BASICS

The major water supply sources in the city of Varna stem from Kamchia Dam-Lake, the Springs of Devnya and the water supply systems of Zlatina, Batova and Pchelnik. Sufficient water resources are available for water supply of the towns and villages around the Varna area. According to data provided by the city, the total length of the water supply network is 4 701 km, with a total of 120 water supply pump stations.

Annual average rainfall (mm)	440
Daily average air temperature (°C)	12.0
% of blue and green area	27.2
% of soil sealed	61.4
% flooded by 1-m sea-level rise	2.5
% flooded by 1-m river-level rise	37.2

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 48%

2036-2065 103%

2066-2095 88%

0 600%

Average % change in population directly affected

2006-2035 31%

2036-2065 117%

2066-2095 95%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DRINKING WATER

The population is 100% provided with water supply. The total amount of produced water amounts to 84 106 m³ per year. In dry months the city suffers from lack of water for irrigating municipal green spaces and for wet-sweeping the streets. In dry years there was also a shortage of drinking water which has led to the well-known and very unpleasant "water regime", when water supply had to be stopped for several hours during the day.

% of drinking water samples complying with drinking water regulation	95.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	60.0
Drinking water consumption (m^3/cap/year)	47.4
Drinking water consumption (litres/cap/day)	132

SEVEROIZTOCHEN

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 5.2 M€

0 300M€

Population directly affected: 103 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

WASTEWATER

Varna and its surroundings 67.5% of the towns and villages (with population over 10 000 inhabitants) are linked to the sewage networks. It covers more than 90% of the population of the city and the town of Devnya, while in the rest of the towns the sewage network has been constructed to accommodate 30-60%. Heavy rains may cause problems to the operation of the wastewater treatment plant, as Varna does not have a separate rainwater drainage system.

% population connected to at least secondary wastewater treatment	43.0
% population connected to tertiary wastewater treatment	1.0
% wastewater that is treated with nutrient-recovering techniques	0.0
% wastewater that is treated with energy-recovering techniques	30.0
Average age of sewer (years)	35
% sewer with separated stormwater and sanitary water	26.0

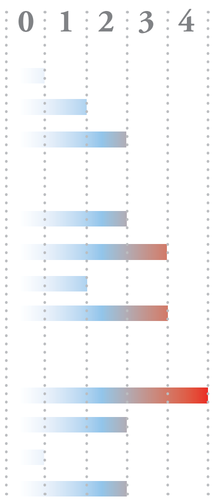
TRENDS & PRESSURES

1.8

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate

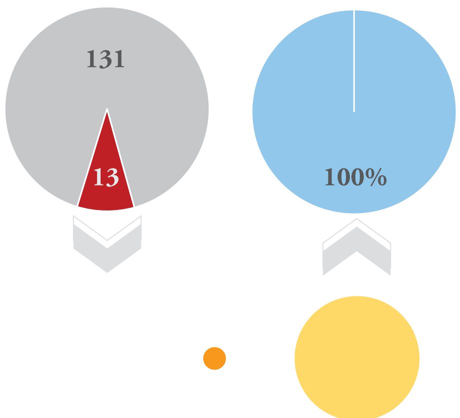


Within this table, lower numbers are better.

Resting boats at the harbour of Varna at sunset.
© Stef Pantova / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



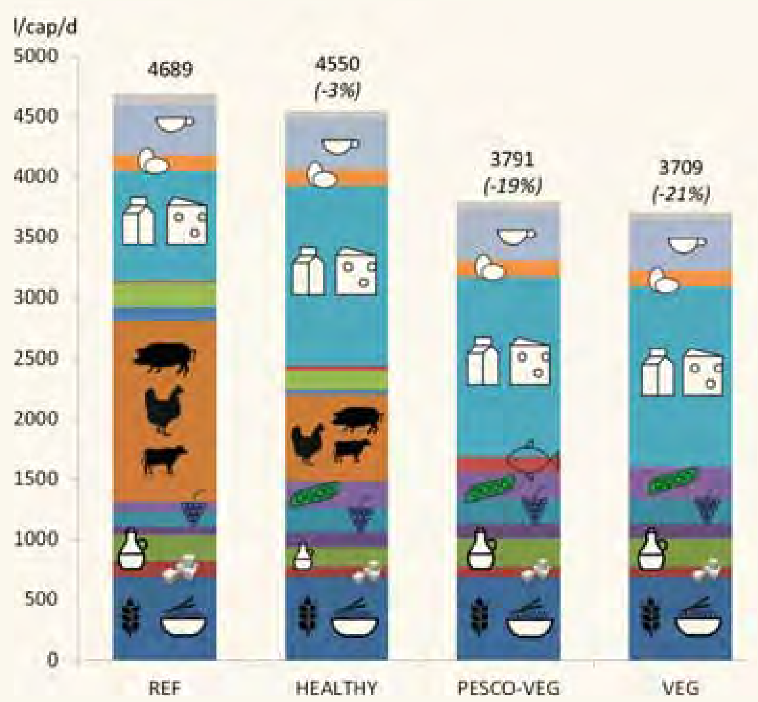
ALERT: 0 WARNING: 2 WATCH: 11

Stress incidents for drought level

VARNA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Varna. Four diet scenarios are shown. The current diet of the inhabitants of Varna leads to a WF of 4 689 l/cap/d, an amount that exceeds the direct water use of the city (47.4 m³/cap/year which equals 132 l/cap/d) substantially. A healthy diet, as recommended by national dietary guidelines, leads to a WF of 4 550 l/cap/d, so a reduction of 3%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 19% reduction to 3 791 l/cap/d) and a vegetarian diet (a 21% reduction to 3 709 l/cap/d). Varna's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

Venlo

51°22'11" N | 6°10'05" E *Country: The Netherlands, Region: Limburg*

National Flag

City Flag

Coat of Arms

People enjoying a drink in the sun in front of the old city hall on the terraces of the Markt square, Venlo. © www.hollandfoto.net / Shutterstock.com

Below: Aerial view of the Floriade Park, Venlo Greenpark. © Aerovista Luchtfotografie / Shutterstock.com

VENLO

Venlo is in the south eastern Netherlands, near the German border, in the province of Limburg. It has a population of 100 000. The city is sited on the River Meuse (or Maas in Dutch), at 21 metres above sea level. International commerce and industry are now important to its economy, it being host to the international headquarters of a number of companies. More traditional horticulture remains important, as it is the second largest concentration of horticultural production and export in the Netherlands, and defined as one of five Greenports.

In 2003, Venlo was awarded the title "Greenest city of Europe". In 2013, it won the 'Best City Centre of the Netherlands' award, demonstrating that attractiveness and citizen well-being remain high in its priorities.

ENVIRONMENTAL QUALITY

Venlo, along with the Limburg province, is working towards the target of becoming the first cradle-to-cradle (c2c) region in the world. The intention is to boost social, economic and environmental welfare internally in the region, whilst at the same time creating a knowledge base that can be exported across Europe and internationally. The programme includes a number of key concepts: continuous material cycles, enhancing water quality, green facades, and renewable energy. The aim is for all of the components to cooperatively enhance the quality and health of the natural and living environments. For example, wastewater is considered a resource for nutrients. Buildings should aim to use only renewable energy.

Resident population (x 1 000)	100
Population density (inhabitants/km²)	777
Waste production kg/cap/year	600
% Recycling and composting	61
% Incineration with energy recovery	38
% Landfill	1

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model

W.E.I. stands for Water Exploitation Index

% SOIL WATER STRESS days during year	W.E.I. DEMAND	W.E.I. CONSUMPTION	Water DEPENDENCY
19.8%	8.2%	2.0%	23.6%

Evapotranspiration difference **(mm/y)**

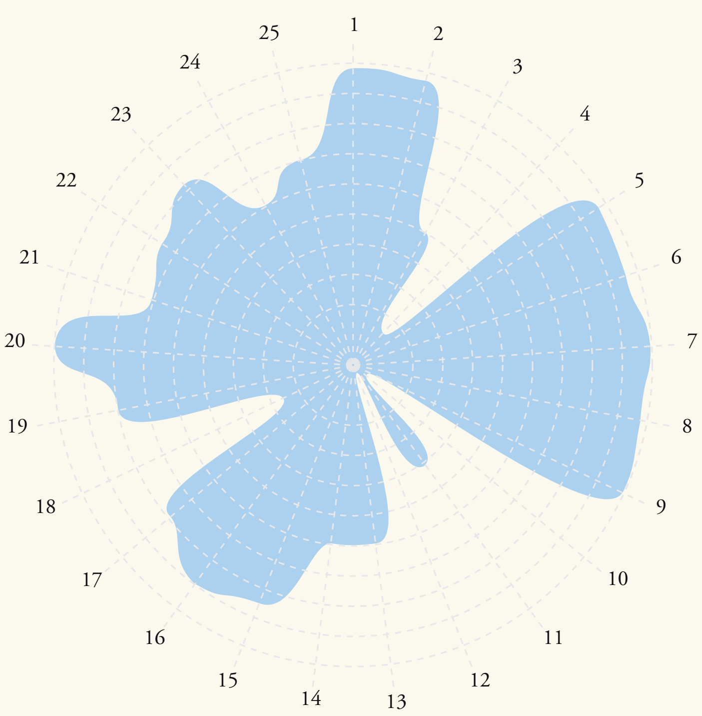
317.6

VENLO

CITY BLUEPRINT ©

Venlo has an excellent solid-waste treatment regime and developed climate adaptation plans. The city can improve its wastewater treatment, reduce the production of solid waste and incorporate more blue-green infrastructure.

The BCI (Blue City Index) **is 5.8**



The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **5.8**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	9.9
2	Tertiary WWT	9.8
3	Groundwater Quality	5.0
4	Solid Waste Collected	1.6
5	Solid Waste Recycled	9.8
6	Solid Waste Energy Recovered	9.7
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.0
11	Energy Recovery	4.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	6.0
14	Average Age Sewer	6.0
15	Operation Cost Recovery	8.5
16	Water System Leakages	9.0
17	Stormwater Separation	8.0
18	Green Space	2.6
19	Climate Adaptation	8.0
20	Drinking Water Consumption	10.0
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.5
23	Public Participation	8.1
24	Water Efficiency Measures	6.0
25	Attractiveness	7.0

Resident Population and Population Density data: EUROSTAT, 2014

References:

Van Leeuwen C.J., Chandy P.C., 2013. The city blueprint: Experiences with the implementation of 24 indicators to assess the sustainability of the urban water cycle. Water Science and Technology: Water Supply, 13.3, 769-781

Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647

Old town houses of cobblestone. © Eivaisla / Shutterstock.com

WATER BASICS

Being on the River Meuse/Maas, water has historically been an important means of transport. The Meuse rises in France and crosses Belgium before entering the Netherlands in Maastricht. Local river water quality is thus dependent on river management in other countries. Venlo is served by the public water utility of Limburg province, run by WML, Limburg Water Company (WML-Waterleiding Maatschappij Limburg).

Annual average rainfall (mm)	750
Daily average air temperature (°C)	9.0
% of blue and green area	24.3
% of soil sealed	57.2
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	4.2

DRINKING WATER

Approximately 75% of Limburg's water supply is from groundwater, from 22 locations, and about 25% from the River Meuse. Like the rest of the Netherlands, careful management allows chlorination to be kept to a minimum, but softening is required. Along the border, WML also purchases water from Germany. The whole supply network is interconnected via a pipeline grid totaling 85 000 km.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	5.0
Drinking water consumption (m^3/cap/year)	45.2
Drinking water consumption (litres/cap/day)	126

WASTEWATER

Sastewater is managed across Limburg by a single, but seperate public utility, WBL (Waterschapbedrijf Limburg). WBL's 18 wastewater treatment plants treat 140 Mm^3/yr from homes, businesses and industry. Biogas is extracted for energy, sludge is dried and processed as fuel for cement kilns in Maastricht, and the cleaned wastewater is returned to streams and rivers in Limburg.

% population connected to at least secondary wastewater treatment	99.3
% population connected to tertiary wastewater treatment	98.1
% wastewater that is treated with nutrient-recovering techniques	0.5
% wastewater that is treated with energy-recovering techniques	40.0
Average age of sewer (years)	30
% sewer with separated stormwater and sanitary water	80.0

Town Hall clock-tower, Venlo.
© Alan Gordine / Shutterstock.com

THE NETHERLANDS

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	229%
2036-2065	22%
2066-2095	296%
0	600%

Average % change in population directly affected

2006-2035	255%
2036-2065	42%
2066-2095	340%
0	750%

Country aggregated data. Changes correspond to high end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

LIMBURG

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 8.6 M€

0 — 300M€

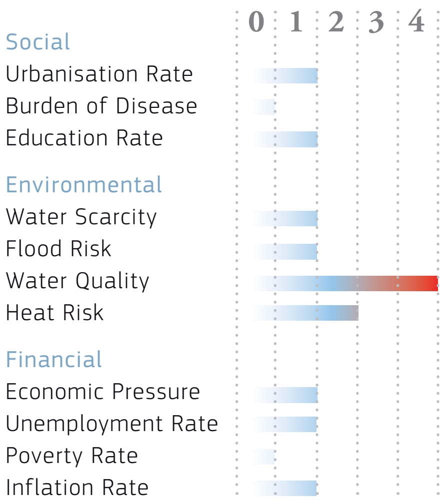
Population directly affected: 781 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

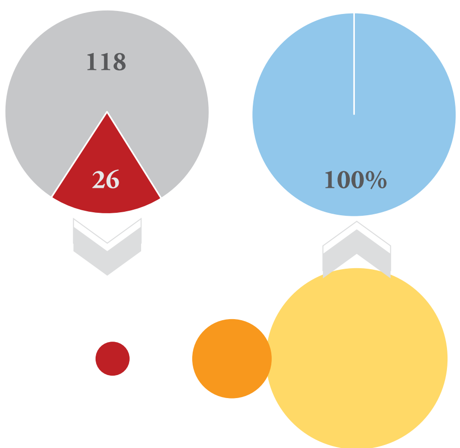
1.1



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



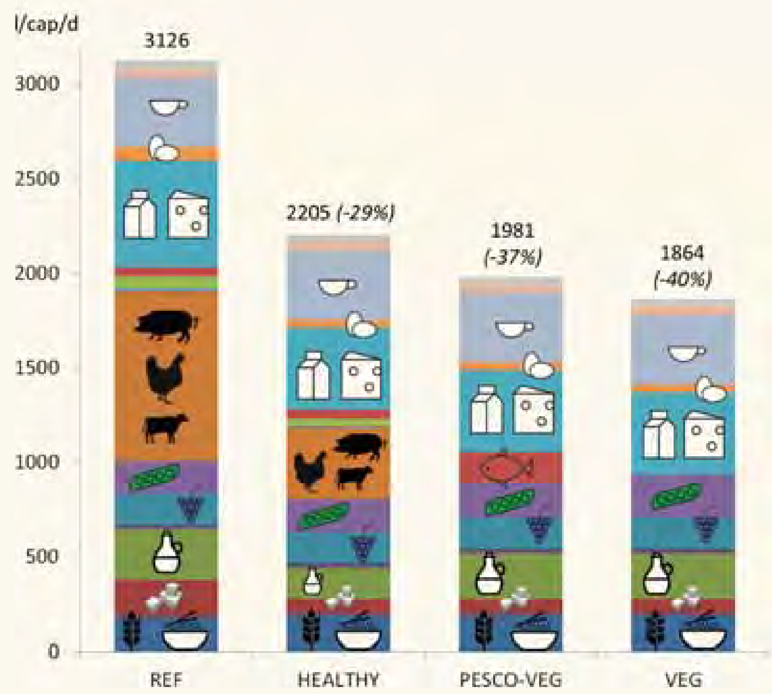
ALERT: 3 WARNING: 7 WATCH: 16

Stress incidents for drought level

VENLO

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Venlo. Four diet scenarios are shown. The current diet of the inhabitants of Venlo leads to a WF of 3 126 l/cap/d, an amount that exceeds the direct water use of the city (45.2 m^3/cap/year which equals 126 l/cap/d) substantially. A healthy diet, as recommended by the Netherlands Nutrition Centre Foundation (Stichting Voedingscentrum Nederland), leads to a WF of 2 205 l/cap/d, so a reduction of 29%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 37% reduction to 1 981 l/cap/d) and a vegetarian diet (a 40% reduction to 1 864 l/cap/d). Venlo's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

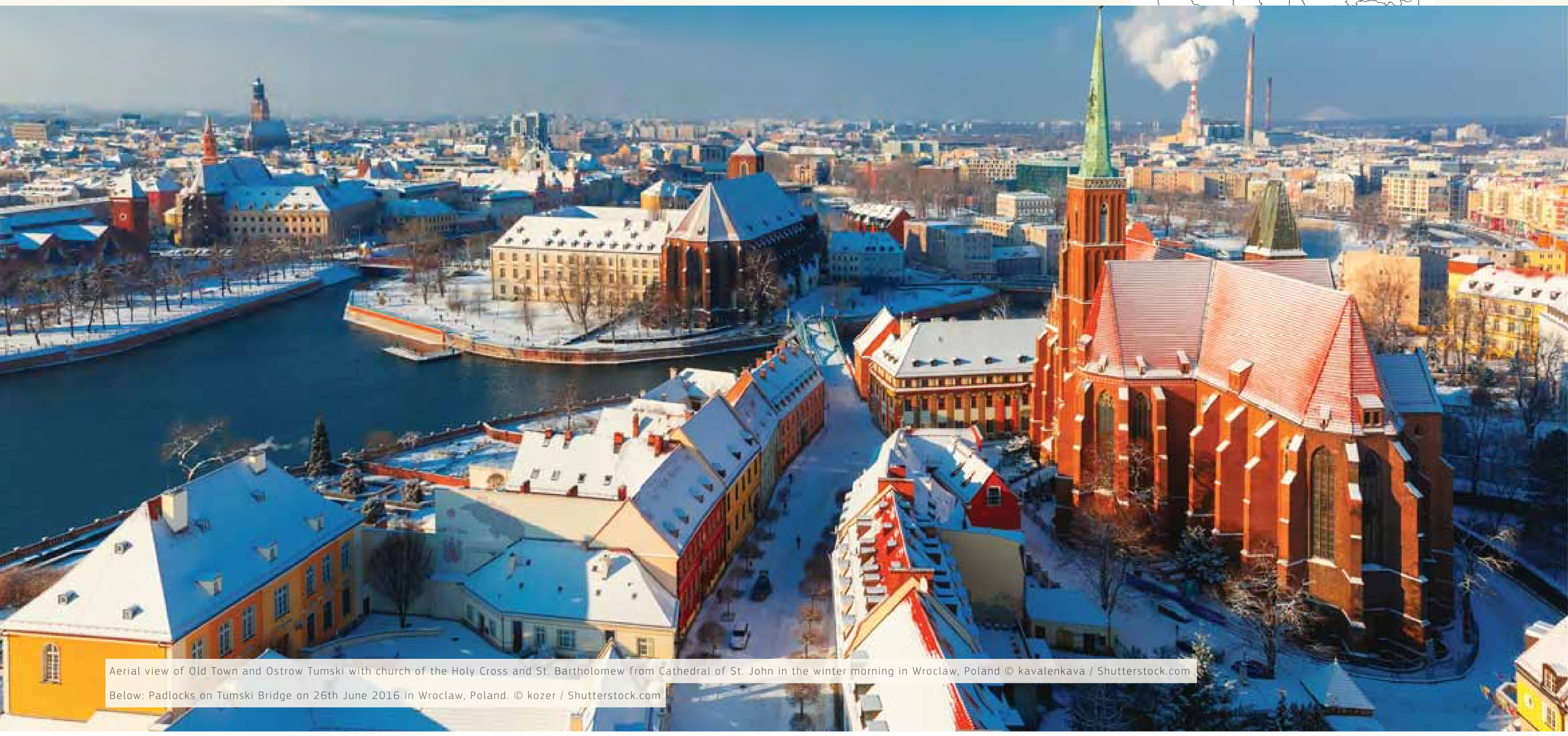
l/cap/d = litres / cap / day

References:
Vanham D., Mak T.N., Gawlik B.M., 2016. Urban food consumption and associated water resources: The example of Dutch cities. Science of the Total Environment, 565, 232–239

Wrocław

51° 6' 28.386'' N | 17° 2' 18.7368'' E *Country: Poland, Region: Lower Silesia*

National Flag City Flag Coat of Arms



Aerial view of Old Town and Ostrow Tumski with church of the Holy Cross and St. Bartholomew from Cathedral of St. John in the winter morning in Wroclaw, Poland © kavalenkava / Shutterstock.com

Below: Padlocks on Tumski Bridge on 26th June 2016 in Wroclaw, Poland. © kozer / Shutterstock.com

WROCŁAW

With a population close to 630 000 and over a million in the wider metropolitan area, Wrocław is the capital of Lower Silesia, and Poland's fourth largest city. It is a major centre for manufacturing, banking, industry, tourism and culture. Wrocław lies in the middle of the Silesian Lowland, with more than 100 bridges, where the Oder River branches out to form 12 islands.

Due to their proximity to both Germany and the Czech Republic, Wrocław and the Lower Silesia region are large import/export partners with those countries.

Wrocław is one of the warmer cities in Poland. Lying between the Trzebnickie Hills and the Sudetes, the mean annual temperature is 8.0°C. The average temperature in January is −0.5°C, with snow common in winter, and 19.9°C in July.

Resident population (x 1 000)	631
Population density (inhabitants/km²)	2 156
Waste production kg/cap/year	320
% Recycling and composting	28
% Incineration with energy recovery	0
% Landfill	71

ENVIRONMENTAL QUALITY

Parks are the hallmark of Wrocław's urban greenery, of which there are 45 in the city, although there are few forests in the area. The commercial power sector is the primary source of air pollution.

Although there are many sources of pollution in the Odra River area, mainly from metallurgy and heavy industry, surface water quality monitoring indicates a clear improving trend.

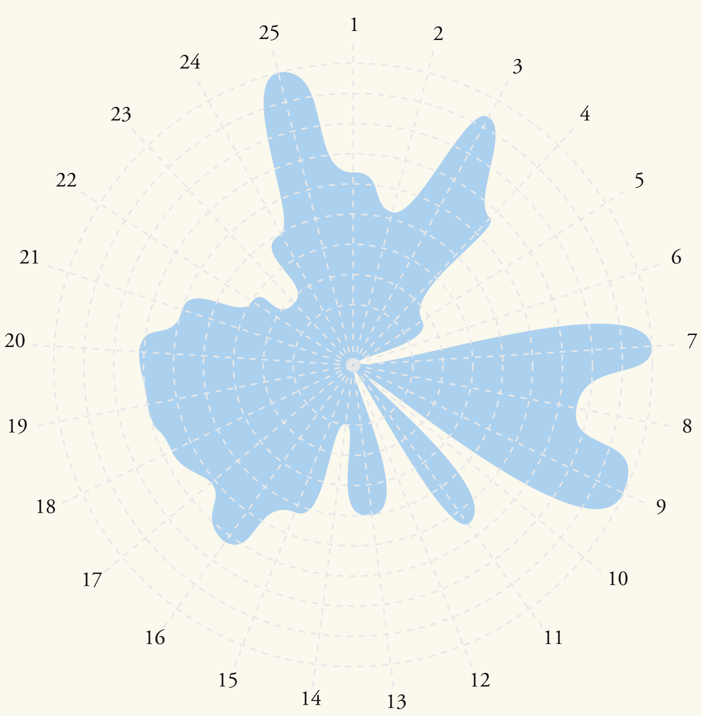
Since joining the EU in 2004, substantial investments have been made to modernise the wastewater treatment plants. According to the classification of the EU's Water Framework Directive, rivers in the city are 'satisfactory' (3rd quality class) and 'good quality' (2nd class).

WROCŁAW

CITY BLUEPRINT ©

Wroclaw water features are greatly contribute to the city's attractiveness. However, the city can make much progress by improving its treatment of both wastewater and solid waste.

The BCI (Blue City Index) **is 4.6**



The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **4.6**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	6.5
2	Tertiary WWT	5.2
3	Groundwater Quality	9.3
4	Solid Waste Collected	6.7
5	Solid Waste Recycled	2.8
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	7.8
9	Drinking Water Quality	10.0
10	Nutrient Recovery	0.3
11	Energy Recovery	6.5
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	2.0
15	Operation Cost Recovery	5.1
16	Water System Leakages	7.2
17	Stormwater Separation	6.1
18	Green Space	6.7
19	Climate Adaptation	7.0
20	Drinking Water Consumption	7.1
21	Climate Robust Buildings	6.0
22	Management and Action Plans	4.0
23	Public Participation	2.9
24	Water Efficiency Measures	5.0
25	Attractiveness	10.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

Cityscape cathedral, river Odra. Wroclaw, Poland, at dusk. © S-F / Shutterstock.com

WATER BASICS

In the 1860s, Wrocław established one of the most advanced urban water supply systems in Europe, which has since evolved and grown. Raw water comes from the Oława River, which also has a connection to the Nysa Kłodzka River. There are two large water treatment plants: Na Grobli (first established in 1871) and Mokry Dwor, with total capacity of 300 000 m³/day for domestic and large industrial demands.

Annual average rainfall (mm)	580
Daily average air temperature (°C)	8.0
% of blue and green area	37.3
% of soil sealed	52.9
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	24.6

DRINKING WATER

The water supply system has an in-built 100% reserve to ensure constant supply in the event of emergency situations. The total length of the network is 1 800 km, including a ring system for greater flexibility. Comprehensive multi-barrier treatment ensures high quality water supply. As with many older cities, the main quality risk is from antique plumbing in many buildings.

% of drinking water samples complying with drinking water regulation	100
% urban population with access to potable drinking water	100
% leakage rate water distribution system	14.0
Drinking water consumption (m³/cap/year)	109.2
Drinking water consumption (litres/cap/day)	303

WASTEWATER

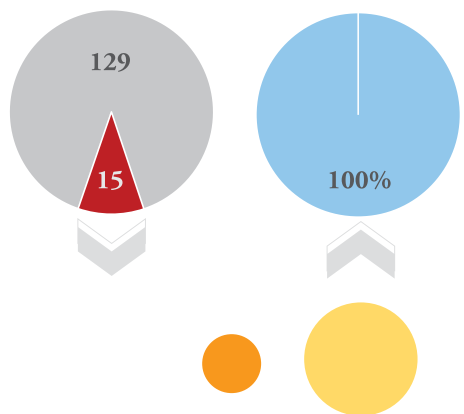
The expansion and modernisation of the Wrocław wastewater treatment plant was a priority investment of the city. It had a strategic importance for the improvement of the environment in the Oder river catchment area and in its receiving waters – the Baltic Sea. The treatment plant capacity was increased from a flow rate of approximately 70 000 m³ to about 140 000 m³ of wastewater per day.

% population connected to at least secondary wastewater treatment	65.0
% population connected to tertiary wastewater treatment	52.0
% wastewater that is treated with nutrient-recovering techniques	5.0
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	50
% sewer with separated stormwater and sanitary water	61.0

Exterior of modern shopping center in Wroclaw. © struvictory / Shutterstock.com

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



ALERT: 0 WARNING: 5 WATCH: 10

Stress incidents for drought level

POLAND

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035	158%
2036-2065	94%
2066-2095	120%
0	600%

Average % change in population directly affected

2006-2035	133%
2036-2065	73%
2066-2095	93%
0	750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

DOLNOSLASKIE

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 74.2 M€

0 — 300M€

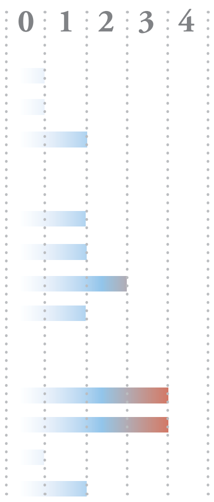
Population directly affected: 3722 inh.

0 — 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

0.6

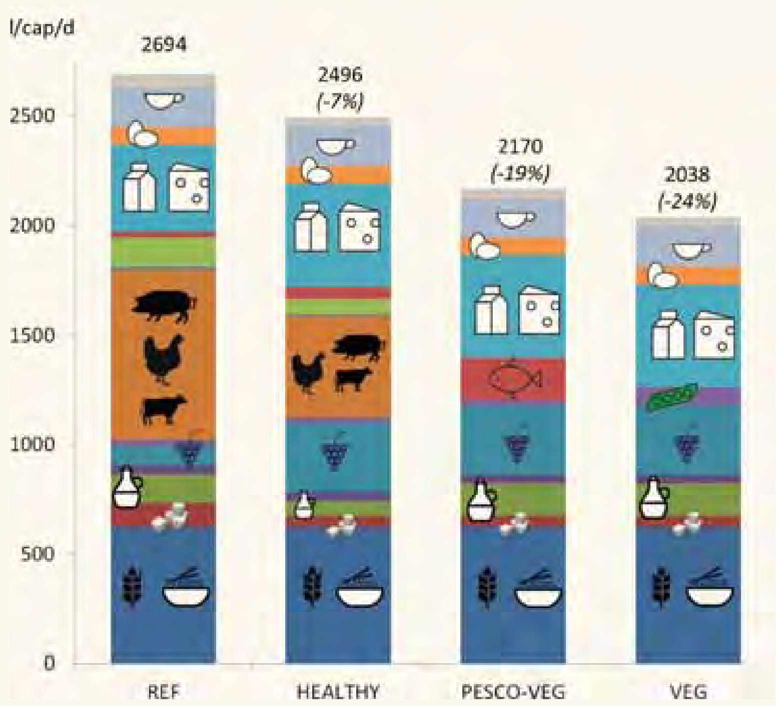


Within this table, lower numbers are better.

WROCŁAW

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Wrocław. Four diet scenarios are shown. The current diet of the inhabitants of Wrocław leads to a WF of 2 694 l/cap/d, an amount that exceeds the direct water use of the city (109.2 m³/cap/year which equals 303 l/cap/d) substantially. A healthy diet, as recommended by national Polish dietary guidelines (zasady racjonalnego żywienia), leads to a WF of 2 496 l/cap/d, so a reduction of 7%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 19% reduction to 2 170 l/cap/d) and a vegetarian diet (a 24% reduction to 2 038 l/cap/d). Wrocław's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

Zaragoza

41°39′21″ N | 0°52′38″ W   *Country: Spain, Region: Aragon*


National Flag


City Flag


Coat of Arms


View of Basilica Pillar in Zaragoza, Spain. © Loredana Cirstea / Shutterstock.com | Below: Detail of expo pavillion in Zaragoza, Spain. © Betelgejze / Shutterstock.com

ZARAGOZA

Zaragoza is the capital of the autonomous community of Aragon, Spain. It lies on the Ebro River and its tributaries, the Huerva and the Gállego, in the centre of the Ebro basin. With a population of around 700 000, it is Spain's 5th largest city, and 4th economically.
With the progressive decline of the agrarian economy, other sectors such as the auto industry have become economic pillars, with benefits also coming from Expo 2008. The city is also home to a Spanish Air Force base.
Zaragoza has a continental Mediterranean climate, with very cold winters and very hot summers. With an average of 330 mm per year, rainfall is low. Summer is dry, with only a few storms in late afternoons. In July and August, temperatures are typically above 30°C, reaching up to 40°C a few days per year.

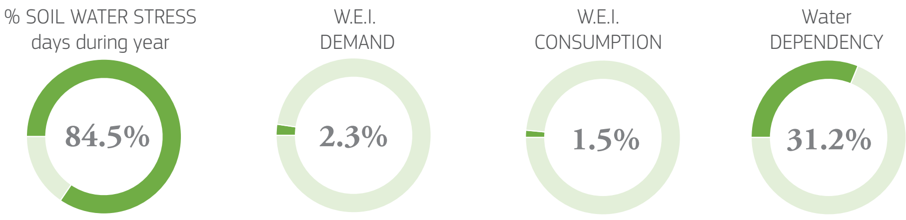
Resident population (x 1 000)	666
Population density (inhabitants/km²)	684
Waste production kg/cap/year	500
% Recycling and composting	29
% Incineration with energy recovery	8
% Landfill	63

ENVIRONMENTAL QUALITY

Zaragoza applies an urban waste management strategy to significantly reduce the waste volumes sent to landfill, and to make recycling and energy recovery a central policy objective.
Thanks to the opening of a waste-treatment complex in 2009, the introduction of selective collection and public awareness campaigns, the rate of household waste recycling has increased from 7% in 2002 to 21% today.
Zaragoza is the most advanced city in Spain for shared electric vehicles, with 3 000 registered users in 2013. A city ordinance has resulted in 18% of taxis having hybrid (combined internal combustion and electric) engines.
Zaragoza has a General Urban Plan and Strategy for biodiversity conservation.

WATER DEMAND & AVAILABILITY

Based on the JRC's LISFLOOD model
W.E.I. stands for Water Exploitation Index



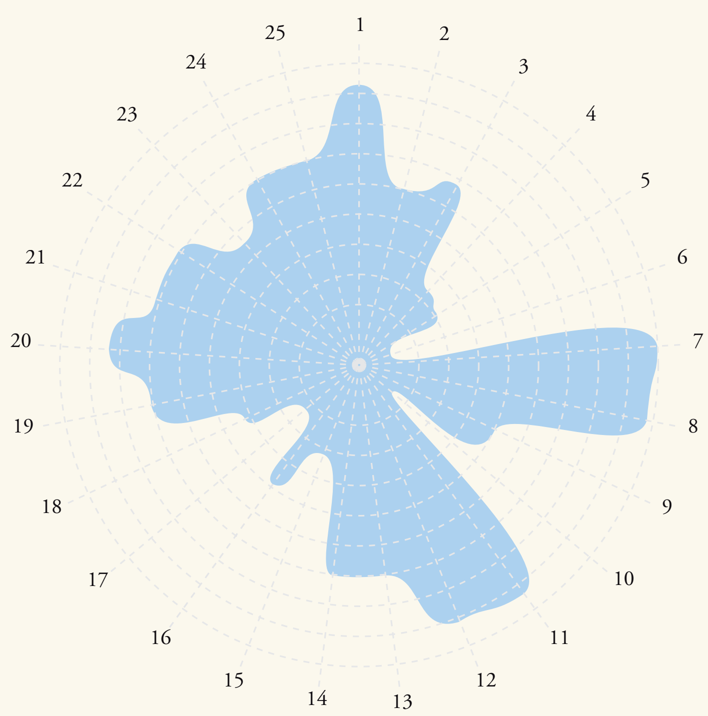
Evapotranspiration difference (**mm/y**)

ZARAGOZA

CITY BLUEPRINT ©

Zaragoza has an adequate wastewater treatment regime and a low level of drinking water consumption. There is room to improve its drinking water quality, solid-waste treatment and nutrient recovery from wastewater.

The BCI (Blue City Index) **is 5.5**



The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **5.5**

derivative reproduction from original CITY BLUEPRINT (TM)

Nr.	Indicator	Score
1	Secondary WWT	9.3
2	Tertiary WWT	6.0
3	Groundwater Quality	6.9
4	Solid Waste Collected	3.4
5	Solid Waste Recycled	3.2
6	Solid Waste Energy Recovered	1.1
7	Access to Drinking Water	10.0
8	Access to Sanitation	9.9
9	Drinking Water Quality	5.0
10	Nutrient Recovery	1.7
11	Energy Recovery	9.3
12	Sewage Sludge Recycling	9.1
13	WWT Energy Efficiency	7.0
14	Average Age Sewer	7.0
15	Operation Cost Recovery	3.1
16	Water System Leakages	5.0
17	Stormwater Separation	2.2
18	Green Space	4.2
19	Climate Adaptation	7.0
20	Drinking Water Consumption	8.3
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.0
23	Public Participation	5.6
24	Water Efficiency Measures	7.0
25	Attractiveness	7.0

Resident Population and Population Density data: EUROSTAT, 2014

References:
Koop S.H.A., Van Leeuwen C.J., 2015a. Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29, 4629-4647
Koop S.H.A., Van Leeuwen C.J., 2015b. Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29, 5649-5670

280-metre-long covered bridge, built in 2008 for the international EXPO. © tomtsya / Shutterstock.com

WATER BASICS

As Zaragoza lies at the confluence of several rivers and canals, flood risk is a major issue. Zaragoza has been highly successful in reducing its overall water consumption, which fall from 136 l/cap/day per capita in 2000 to 100 l/cap/day in 2012, making it among the lowest in Europe. Water efficiency plans for 2020 are also ambitious. The source of drinking water is the Ebro River, Spain's largest.

Annual average rainfall (mm)	330
Daily average air temperature (°C)	15.0
% of blue and green area	29.4
% of soil sealed	52.9
% flooded by 1-m sea-level rise	0.0
% flooded by 1-m river-level rise	35.0

DRINKING WATER

Water from the Ebro River is transferred to Zaragoza via 110 km of the "Canal Imperial de Aragon". Raw water quality in Zaragoza is affected by the seasonal fluctuations of the Ebro River. The introduction of new supply options linked to water sources in the Pyrenees mountains via the Yesa reservoir, results in reduced treatment costs and overall better water quality.

% of drinking water samples complying with drinking water regulation	50.0
% urban population with access to potable drinking water	100
% leakage rate water distribution system	25.2
Drinking water consumption (m^3/cap/year)	81.7
Drinking water consumption (litres/cap/day)	227

WASTEWATER

Zaragoza has two wastewater treatment plants with secondary and tertiary treatments to remove phosphorus: La Almozara plant with 100 000 people equivalent (pe) capacity and La Cartuja plant with 1 200 000 PE capacity. The latter has a steam turbine that uses extracted heat to generate 3 588 300 kWh of electricity. Sewage sludge is recycled for thermal processing or applied to agriculture.

% population connected to at least secondary wastewater treatment	93.0
% population connected to tertiary wastewater treatment	60.0
% wastewater that is treated with nutrient-recovering techniques	18.0
% wastewater that is treated with energy-recovering techniques	100
Average age of sewer (years)	25
% sewer with separated stormwater and sanitary water	21.7

Commercial street in Zaragoza.
© Matyas Rehak / Shutterstock.com

SPAIN

PROJECTED FLOOD RISK

Average % change in economic damage

2006-2035 45%

2036-2065 89%

2066-2095 123%

0 600%

Average % change in population directly affected

2006-2035 52%

2036-2065 72%

2066-2095 114%

0 750%

Country aggregated data. Changes correspond to high-end global warming scenarios (i.e. around 4 degrees of warming by 2100, as compared to pre-industrial levels).
These indicators refer to river flooding only (not including the effect of flash floods, coastal floods or sea-level rise).

ARAGON

AVERAGE ANNUAL FLOOD RISK

Flood direct economic damage: 6.3 M€

0 300M€

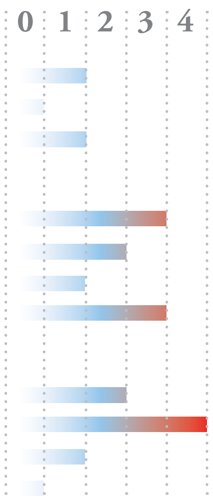
Population directly affected: 943 inh.

0 20K inh.

Data shown are probabilistic estimates of the annual flood impact aggregated over NUTS2 regions, and are based on hydrological simulations for the period 1990-2013.
These indicators refer to river flooding only.
(not including the effect of flash floods or of coastal floods).

TRENDS & PRESSURES

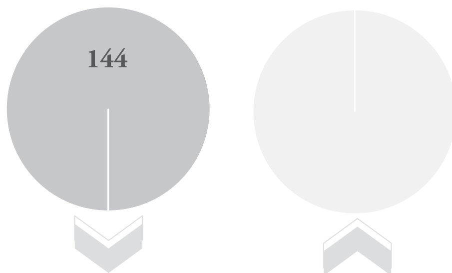
1.6



Within this table, lower numbers are better.

DROUGHT STATUS:

- Number of stress incidents related to drought
- Number of normal events
- Partial recovery after a drought episode
- Full recovery after a drought episode



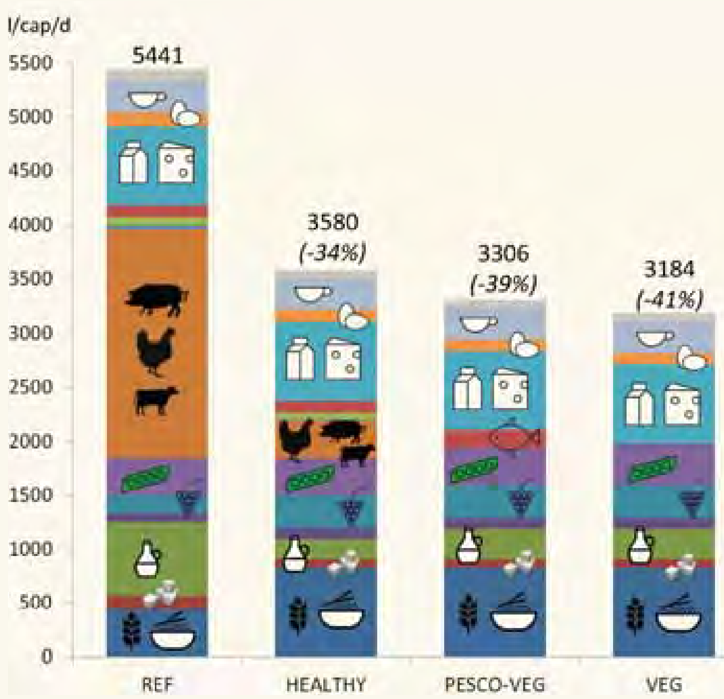
ALERT: 0 WARNING: 0 WATCH: 0

Stress incidents for drought level

ZARAGOZA

WATER FOOTPRINT

- Alcoholic Beverages
- Spices
- Stimulants
- Eggs
- Milk and milk products
- Fish and seafood
- Animal fats
- Offals
- Meat
- Pulses, nuts and oilcrops
- Fruit
- Vegetables
- Crop oils
- Sugar
- Cereals, potatoes



This figure shows the water footprint (WF) related to food consumption for Zaragoza. Four diet scenarios are shown. The current diet of the inhabitants of Zaragoza leads to a WF of 5 441 l/cap/d, an amount that exceeds the direct water use of the city (81.7 m^3/cap/yr which equals 227 l/cap/d) substantially. A healthy Mediterranean diet leads to a WF of 3 580 l/cap/d, so a reduction of 34%. Even greater reductions in the WF are observed for a pesco-vegetarian diet (a 39% reduction to 3 306 l/cap/d) and a vegetarian diet (a 41% reduction to 3 184 l/cap/d). Zaragoza's citizens can thus save a lot of water by looking at their indirect water use, through a change in their diet.

l/cap/d = litres / cap / day

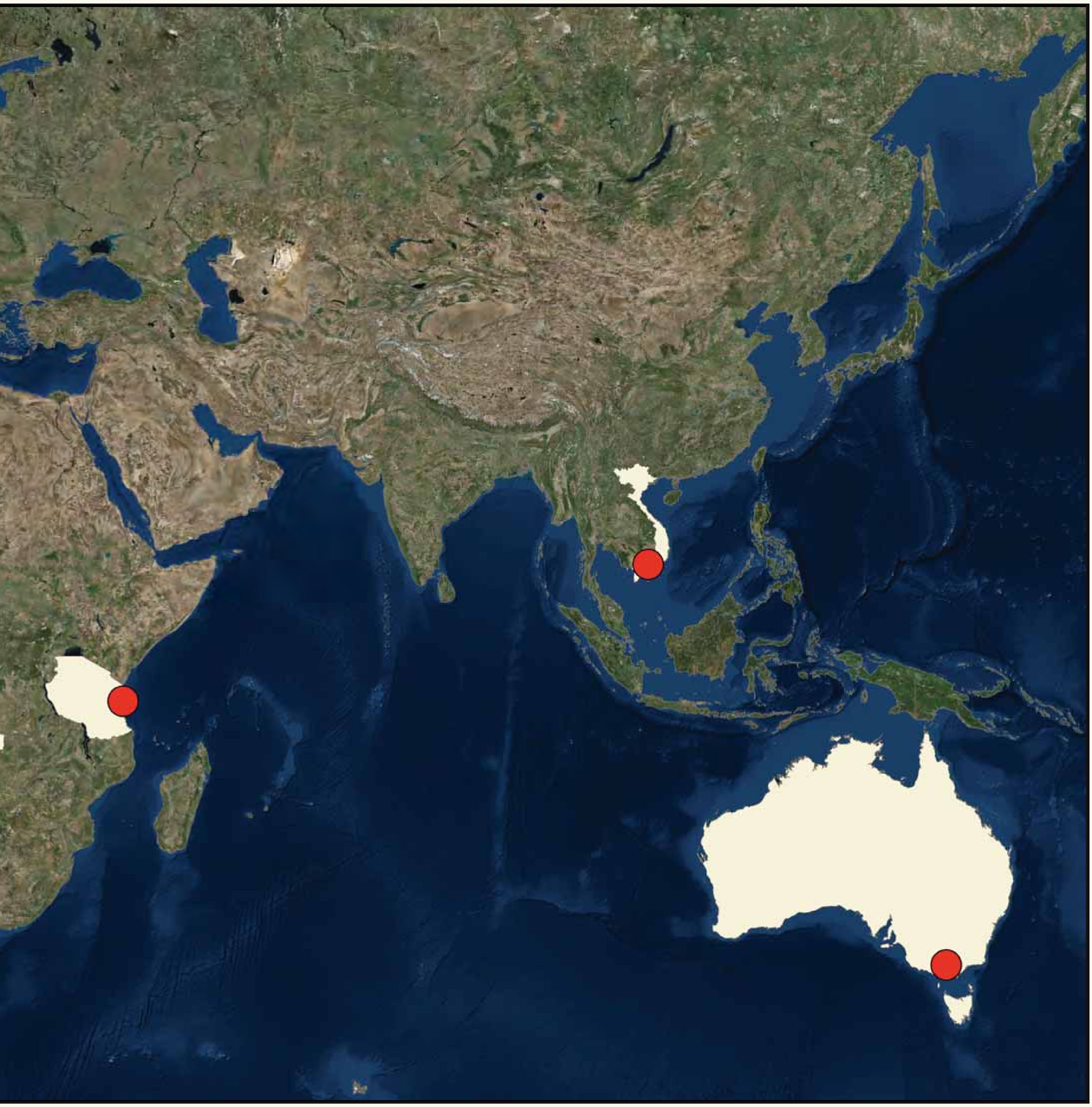
References:
Vanham D., del Pozo S., Pekcan A.G., Keinan-Boker L., Trichopoulou A., Gawlik B.M., 2016. Water consumption related to different diets in Mediterranean cities. Science of the Total Environment, 573, 96-105

CITY BLUEPRINT

THE GLOBAL PERSPECTIVE

The City Blueprint® is a practical communication tool that can help cities on their path to become sustainable water-wise cities. Its versatility and applicability have been shown for the wider European area, but the tool can easily be used across the globe. In the following, we show examples of its applicability to selected cities outside Europe as well as its usefulness to assess country performance. The City Blueprint® reveals, at a glance, precisely where a city's strong and weak points lie and can serve as the key first step in strategic long-term planning to establish a city as sustainable and water-wise. It is an easy-to-understand interactive tool that serves strategic decisions, and the actual assessment, carried out together with key stakeholders, ensures usable results and quick access to expert knowledge.

The City Blueprint® offers a platform that enhances city-to-city learning and exchange of best practices. Cities can learn important practical lessons from other cities that have already implemented best practices.



Belém

Country: Brazil

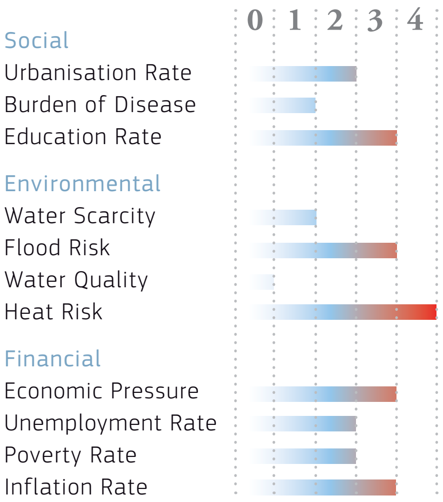
National Flag

City Flag

Coat of Arms

TRENDS & PRESSURES

2.2



Within this table, lower numbers are better.

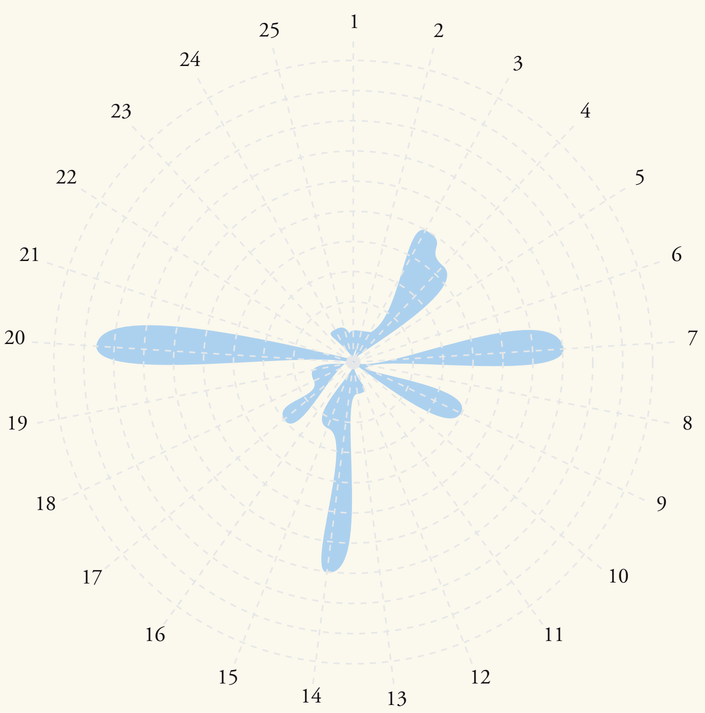
BELÉM

CITY BLUEPRINT ©

The BCI (Blue City Index) **is 1.1**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **1.1**

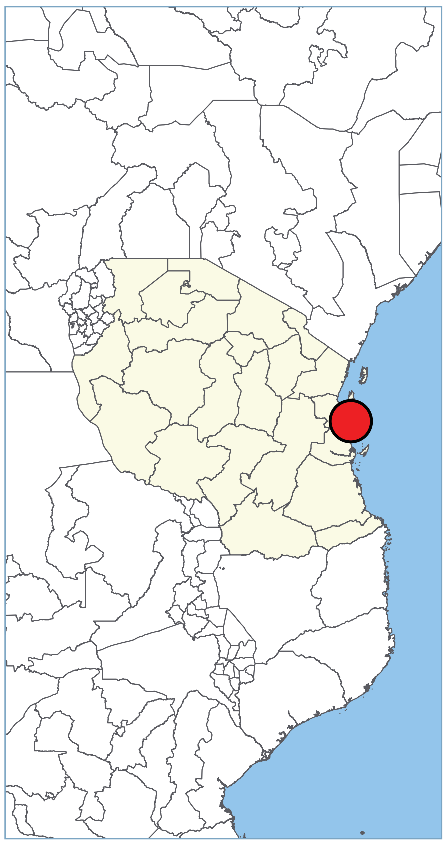


Nr.	Indicator	Score
1	Secondary WWT	0.8
2	Tertiary WWT	0.8
3	Groundwater Quality	5.0
4	Solid Waste Collected	4.5
5	Solid Waste Recycled	0.0
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	7.0
8	Access to Sanitation	0.7
9	Drinking Water Quality	4.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	1.0
14	Average Age Sewer	7.0
15	Operation Cost Recovery	2.4
16	Water System Leakages	0.4
17	Stormwater Separation	3.0
18	Green Space	1.3
19	Climate Adaptation	0.0
20	Drinking Water Consumption	8.8
21	Climate Robust Buildings	0.0
22	Management and Action Plans	0.0
23	Public Participation	0.0
24	Water Efficiency Measures	1.0
25	Attractiveness	0.0

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Dar es Salaam

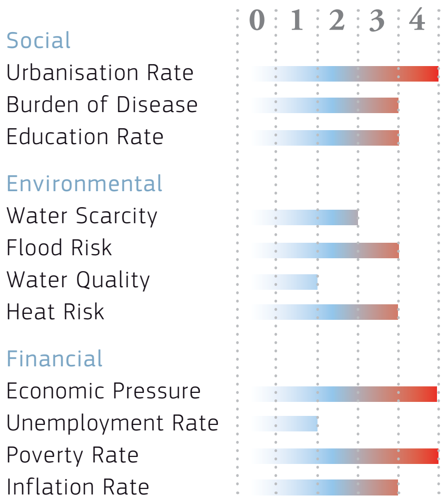
Country: Tanzania



National Flag

TRENDS & PRESSURES

2.8



Within this table, lower numbers are better.

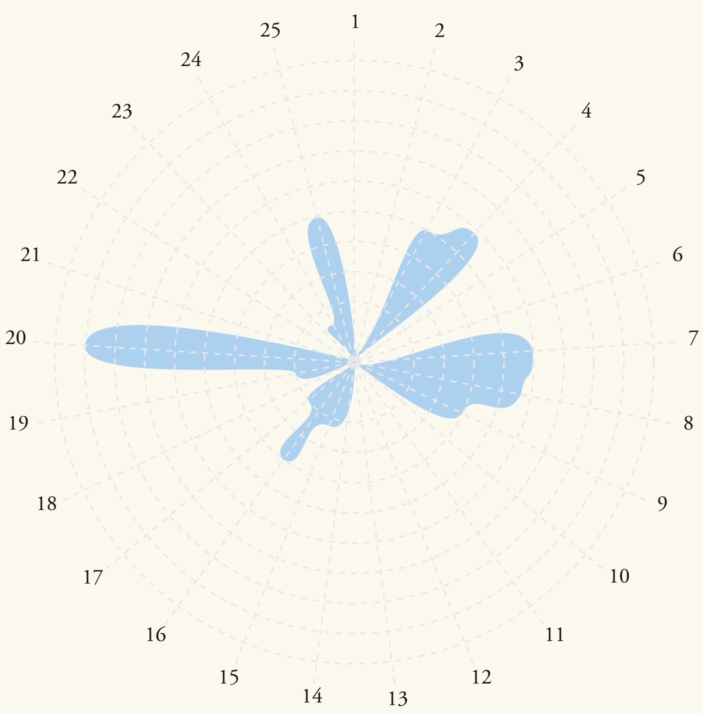
DAR ES SALAAM

CITY BLUEPRINT ©

The BCI (Blue City Index) **is 1.4**

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **1.4**



Nr.	Indicator	Score
1	Secondary WWT	0.1
2	Tertiary WWT	0.0
3	Groundwater Quality	5.0
4	Solid Waste Collected	5.9
5	Solid Waste Recycled	0.5
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	6.0
8	Access to Sanitation	5.6
9	Drinking Water Quality	4.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	0.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	2.2
16	Water System Leakages	4.0
17	Stormwater Separation	2.0
18	Green Space	0.0
19	Climate Adaptation	2.0
20	Drinking Water Consumption	9.0
21	Climate Robust Buildings	2.0
22	Management and Action Plans	2.0
23	Public Participation	0.0
24	Water Efficiency Measures	2.0
25	Attractiveness	5.0

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Ho Chi Minh City

Country: Vietnam

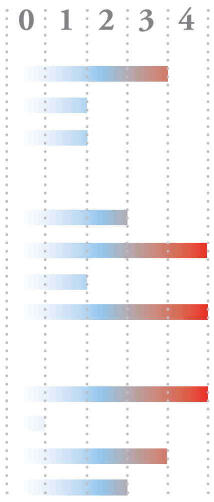
National Flag

TRENDS & PRESSURES 2.2

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate



Within this table, lower numbers are better.

Kilamba Kiaxi

Country: Angola

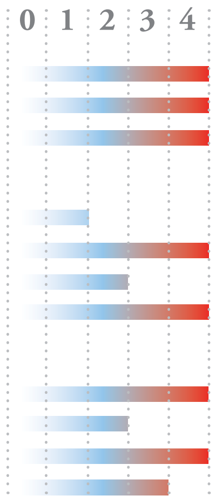
National Flag

TRENDS & PRESSURES 3.2

Social
Urbanisation Rate
Burden of Disease
Education Rate

Environmental
Water Scarcity
Flood Risk
Water Quality
Heat Risk

Financial
Economic Pressure
Unemployment Rate
Poverty Rate
Inflation Rate



Within this table, lower numbers are better.

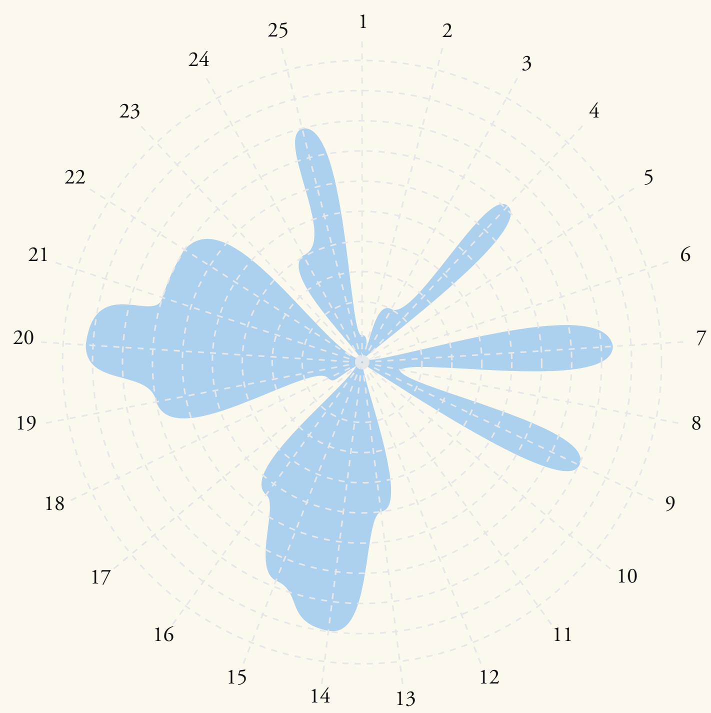
HO CHI MINH CITY

CITY BLUEPRINT ©

The BCI (Blue City Index) **is 2.4**

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **2.4**



Nr.	Indicator	Score
1	Secondary WWT	0.6
2	Tertiary WWT	0.0
3	Groundwater Quality	2.0
4	Solid Waste Collected	7.1
5	Solid Waste Recycled	0.5
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	8.4
8	Access to Sanitation	1.2
9	Drinking Water Quality	8.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	5.0
14	Average Age Sewer	9.0
15	Operation Cost Recovery	7.9
16	Water System Leakages	5.4
17	Stormwater Separation	0.1
18	Green Space	1.3
19	Climate Adaptation	7.0
20	Drinking Water Consumption	9.3
21	Climate Robust Buildings	7.0
22	Management and Action Plans	7.0
23	Public Participation	0.0
24	Water Efficiency Measures	4.0
25	Attractiveness	8.0

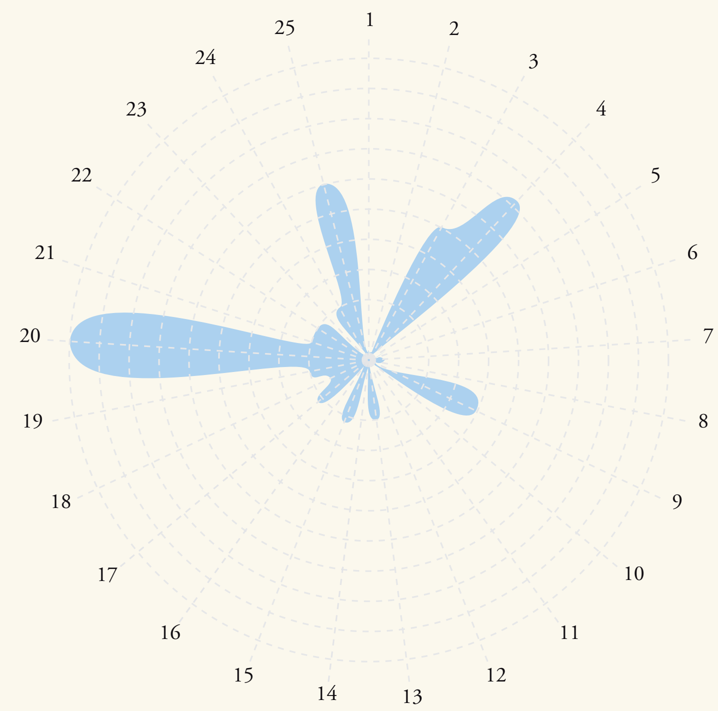
KILAMBA KIAXI

CITY BLUEPRINT ©

The BCI (Blue City Index) **is 1.1**

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **1.1**



Nr.	Indicator	Score
1	Secondary WWT	0.0
2	Tertiary WWT	0.0
3	Groundwater Quality	5.0
4	Solid Waste Collected	7.2
5	Solid Waste Recycled	0.0
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	0.4
8	Access to Sanitation	0.0
9	Drinking Water Quality	4.0
10	Nutrient Recovery	0.0
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	0.0
13	WWT Energy Efficiency	2.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	2.2
16	Water System Leakages	0.0
17	Stormwater Separation	2.0
18	Green Space	1.3
19	Climate Adaptation	2.0
20	Drinking Water Consumption	10.0
21	Climate Robust Buildings	2.0
22	Management and Action Plans	2.0
23	Public Participation	0.0
24	Water Efficiency Measures	2.0
25	Attractiveness	6.0

References:
Van Leeuwen CJ, Dan NP and Dieperink C (2016) The challenges of water governance in Ho Chi Minh City. Integrated Environmental Assessment and Management, 12:345-352
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Malta

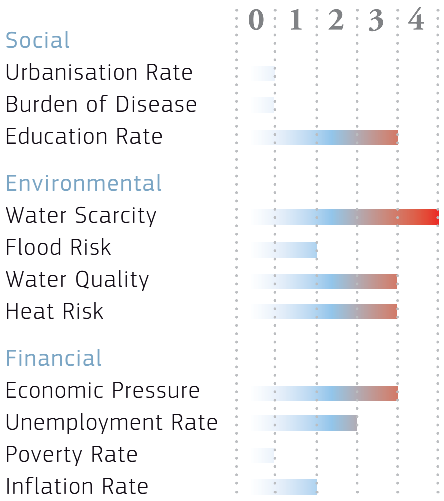
Country: Malta

National Flag

Coat of Arms

TRENDS & PRESSURES

1.7



Within this table, lower numbers are better.

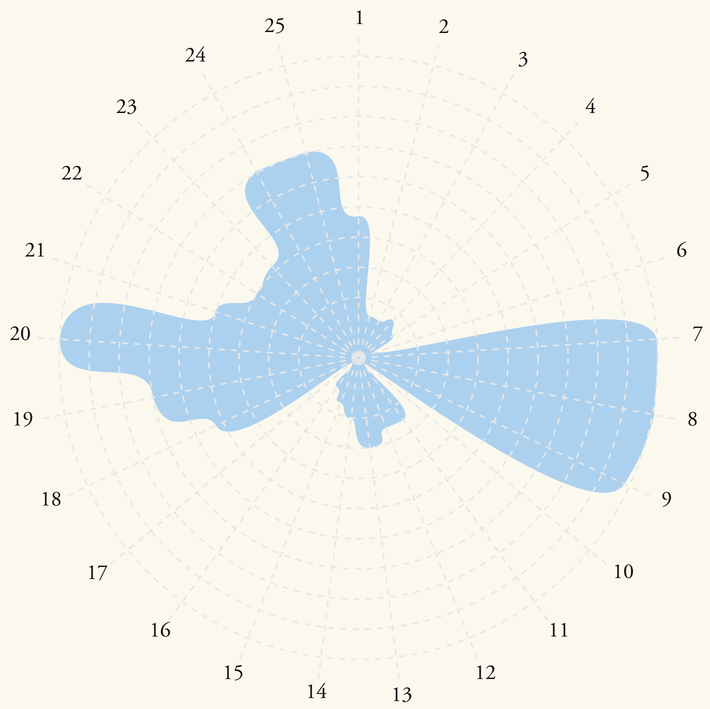
MALTA

CITY BLUEPRINT ©

The BCI (Blue City Index) **is 3.0**

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **3.0**



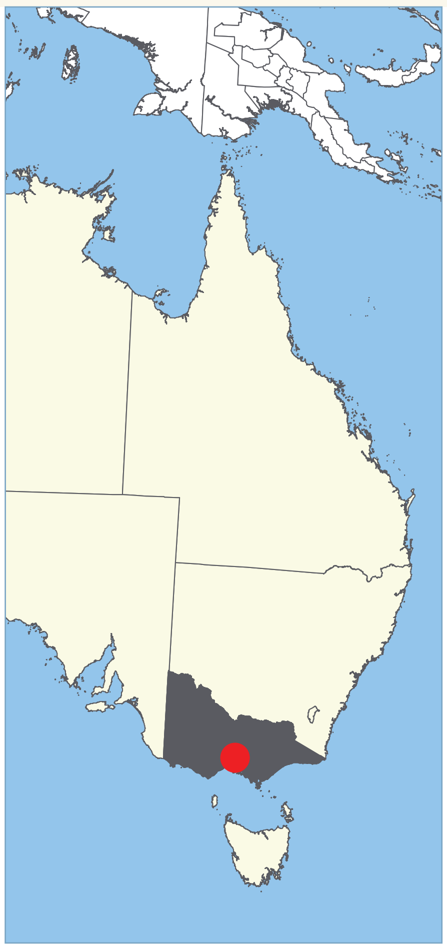
Nr.	Indicator	Score
1	Secondary WWT	4.8
2	Tertiary WWT	1.3
3	Groundwater Quality	1.3
4	Solid Waste Collected	1.8
5	Solid Waste Recycled	1.3
6	Solid Waste Energy Recovered	0.0
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	9.9
10	Nutrient Recovery	0.0
11	Energy Recovery	2.4
12	Sewage Sludge Recycling	2.4
13	WWT Energy Efficiency	3.0

Nr.	Indicator	Score
14	Average Age Sewer	2.0
15	Operation Cost Recovery	1.6
16	Water System Leakages	1.2
17	Stormwater Separation	0.0
18	Green Space	5.2
19	Climate Adaptation	7.0
20	Drinking Water Consumption	10.0
21	Climate Robust Buildings	5.0
22	Management and Action Plans	4.0
23	Public Participation	4.2
24	Water Efficiency Measures	7.0
25	Attractiveness	7.0

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

Melbourne

Country: Australia



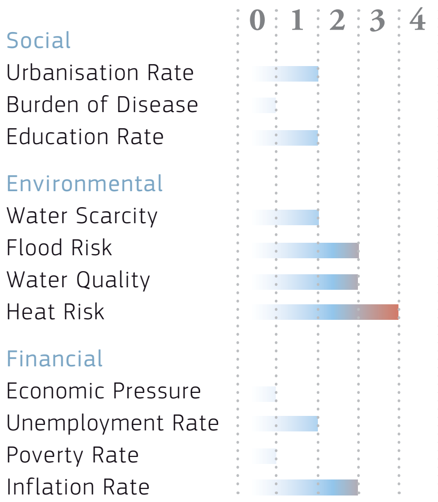
National Flag

City Flag

Coat of Arms

TRENDS & PRESSURES

1.2



Within this table, lower numbers are better.

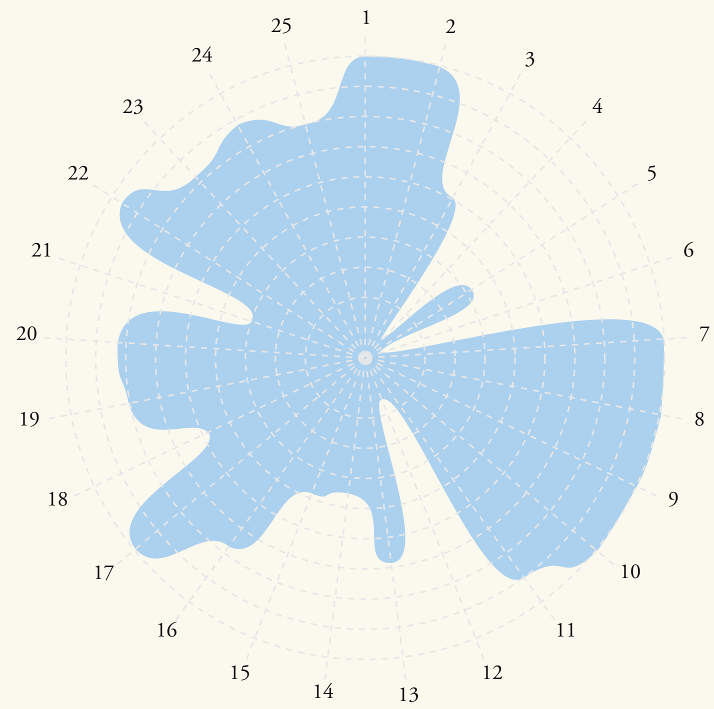
MELBOURNE

CITY BLUEPRINT ©

The BCI (Blue City Index) **is 6.1**

The range of the scores varies from
0 (centre of the circle) to
10 (periphery of the circle).

The Blue City Index is **6.1**



Nr.	Indicator	Score
1	Secondary WWT	10.0
2	Tertiary WWT	10.0
3	Groundwater Quality	6.0
4	Solid Waste Collected	0.9
5	Solid Waste Recycled	4.1
6	Solid Waste Energy Recovered	0.2
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	10.0
11	Energy Recovery	9.0
12	Sewage Sludge Recycling	1.4
13	WWT Energy Efficiency	6.9

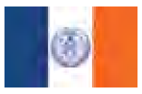
Nr.	Indicator	Score
14	Average Age Sewer	4.4
15	Operation Cost Recovery	4.9
16	Water System Leakages	7.8
17	Stormwater Separation	10.0
18	Green Space	5.9
19	Climate Adaptation	8.0
20	Drinking Water Consumption	8.1
21	Climate Robust Buildings	4.0
22	Management and Action Plans	9.5
23	Public Participation	8.2
24	Water Efficiency Measures	8.8
25	Attractiveness	8.0

References:
Van Leeuwen CJ (2015) Water governance and the quality of water services in the city of Melbourne. Urban Water Journal. DOI 10.1080/1573062X.2015
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7

New York

Country: United States

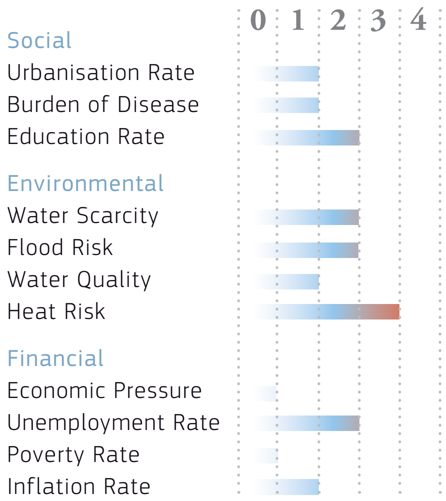

National Flag


City Flag


Coat of Arms

TRENDS & PRESSURES

1.4



Within this table, lower numbers are better.

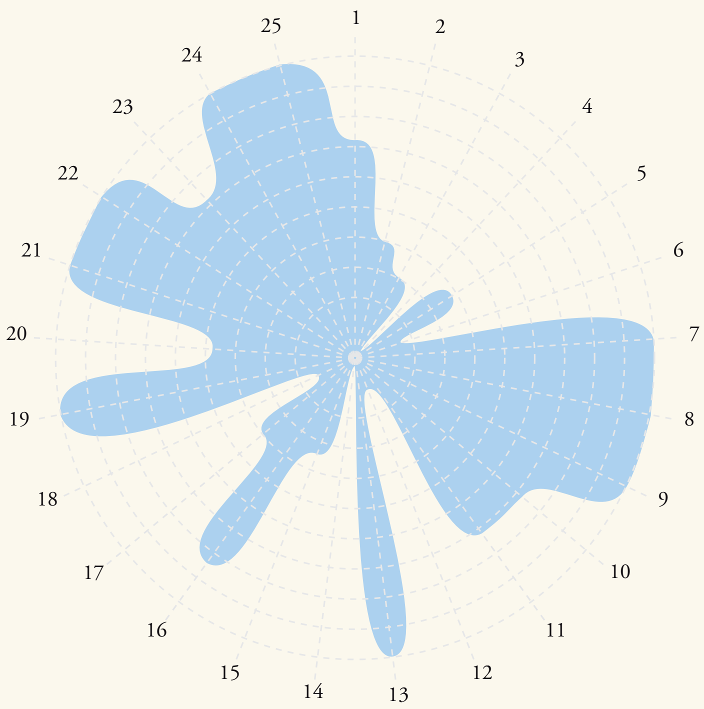
NEW YORK

CITY BLUEPRINT ©

The BCI (Blue City Index) is 4.8

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

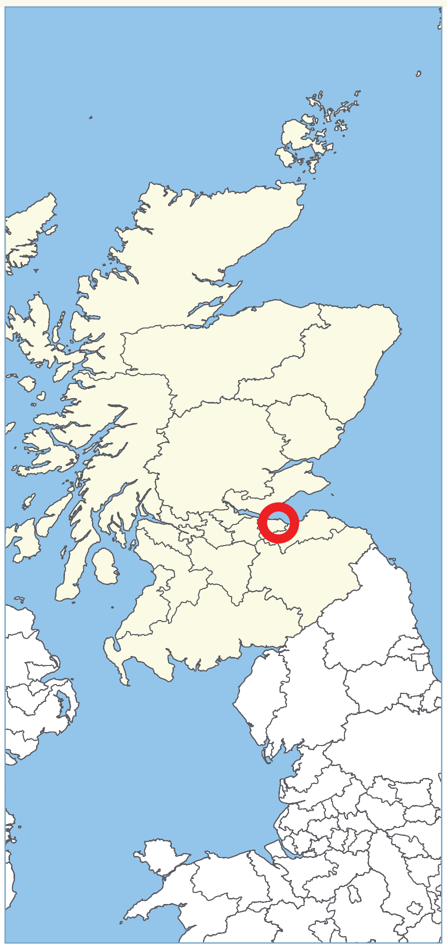
The Blue City Index is **4.8**



Nr.	Indicator	Score
1	Secondary WWT	7.2
2	Tertiary WWT	4.0
3	Groundwater Quality	3.0
4	Solid Waste Collected	0.0
5	Solid Waste Recycled	3.9
6	Solid Waste Energy Recovered	1.8
7	Access to Drinking Water	10.0
8	Access to Sanitation	10.0
9	Drinking Water Quality	10.0
10	Nutrient Recovery	7.2
11	Energy Recovery	7.2
12	Sewage Sludge Recycling	0.7
13	WWT Energy Efficiency	10.0
14	Average Age Sewer	0.0
15	Operation Cost Recovery	3.4
16	Water System Leakages	8.4
17	Stormwater Separation	4.0
18	Green Space	1.3
19	Climate Adaptation	10.0
20	Drinking Water Consumption	4.7
21	Climate Robust Buildings	10.0
22	Management and Action Plans	10.0
23	Public Participation	7.2
24	Water Efficiency Measures	10.0
25	Attractiveness	10.0

Scotland

Country: United Kingdom

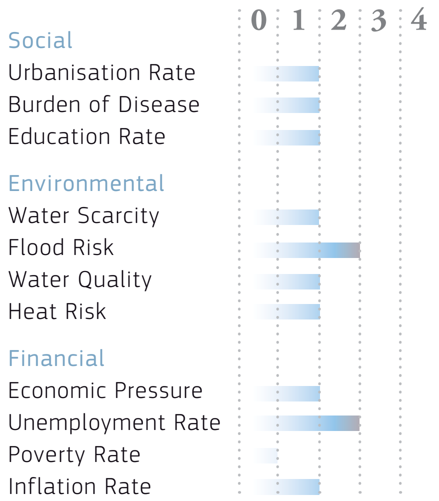



National Flag


Coat of Arms

TRENDS & PRESSURES

1.1



Within this table, lower numbers are better.

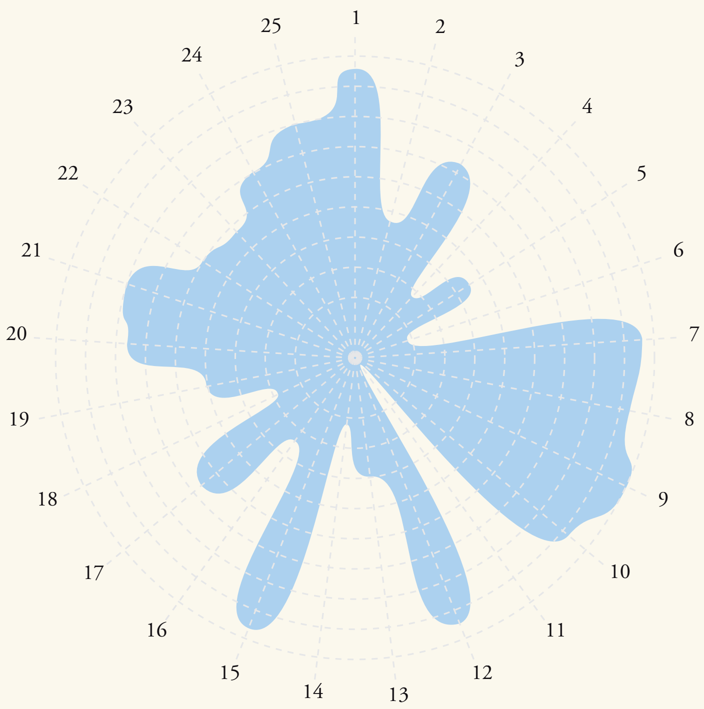
SCOTLAND

CITY BLUEPRINT ©

The BCI (Blue City Index) is 5.4

The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle).

The Blue City Index is **5.4**



Nr.	Indicator	Score
1	Secondary WWT	9.7
2	Tertiary WWT	4.7
3	Groundwater Quality	7.4
4	Solid Waste Collected	2.9
5	Solid Waste Recycled	4.5
6	Solid Waste Energy Recovered	1.9
7	Access to Drinking Water	9.7
8	Access to Sanitation	9.3
9	Drinking Water Quality	10.0
10	Nutrient Recovery	9.4
11	Energy Recovery	0.0
12	Sewage Sludge Recycling	9.4
13	WWT Energy Efficiency	4.0
14	Average Age Sewer	2.2
15	Operation Cost Recovery	9.7
16	Water System Leakages	3.4
17	Stormwater Separation	6.6
18	Green Space	2.9
19	Climate Adaptation	5.0
20	Drinking Water Consumption	7.7
21	Climate Robust Buildings	8.0
22	Management and Action Plans	6.0
23	Public Participation	5.8
24	Water Efficiency Measures	7.0
25	Attractiveness	8.0

References:
Koop SHA and Van Leeuwen CJ (2015) Application of the Improved City Blueprint Framework in 45 municipalities and regions. Water Resources Management, 29:4629-4647. Open Access on SpringerLink: http://link.springer.com/article/10.1007/s11269-015-1079-7
Koop SHA and Van Leeuwen CJ (2015) Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29:5649-5670

INTER CITIES

134 | INTERCITIES

–

136-139 **The Dubrovnik Process**
140-145 **Applied SciArt Water Diplomacy**
146-148 **Emerging heads**
149 **NETWERC H2O**
150-151 **Making cities smarter – The BlueSCities Project**

Uncontrolled water
(Niekontrolowana woda)
Natalia Głowacka, 2016
Częstochowa, Poland

100 x 70
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas

The Dubrovnik **Process**

Mayors, Water Engineers and Citizens of the DUBROVNIK Group discussing on water issues in an urban setting. © Ricardo Rodrigues da Silva

THE DUBROVNIK DECLARATION OF INTENT

In the Autumn of 2015, Dubrovnik, the Croatian capital of the Adriatic, hosted a gathering of international experts on water and city representatives from the Balkans, Eastern Europe, the United Kingdom, Turkey and the Middle East intent on mutual collaboration and the construction of an alliance to be known as the Dubrovnik Group, designed to promote and improve how water, our most valuable natural resource is managed.

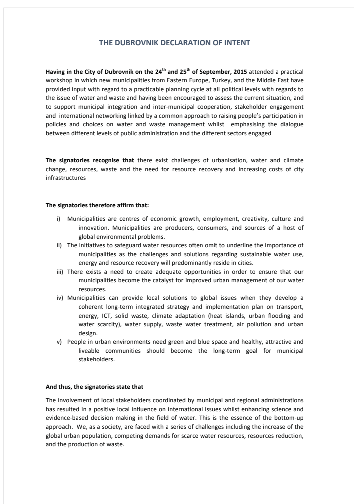
Organised by the Joint Research Centre (the European Commission's science and knowledge service), NETWERC H2O, (The Network for Water in European Regions and Cities) and the partners of the European-founded project, BlueSCities, the two-day workshop entitled, 'Winning by Twinning' investigated the importance of the role of local administrations in resolving international environmental issues. Working and conversing with experts from the UN, the European Commission, and academic representatives from Europe and the USA, the participants created a joint document entitled the **Dubrovnik Declaration of Intent**, in which they stated their willingness to work together on future actions so that citizen awareness and citizen engagement at a municipal level would become a major factor in the war on drought and other water-based crises.

Dubrovnik was not chosen by chance. A city which, over the centuries, has been witness to the consequences of so many conflicts, was deemed a symbolically important venue in which to create the foundations of an alliance which would seek to overcome historical national and regional cultural barriers in order to address the potential geopolitical instability and tensions based on the need to have access to water.

Such instability and tension has always existed in many parts of the World. But the situation is worsening. In 2014, a billion people, or one in seven people on the planet, already lacked access to safe drinking water and, while many northern and tropical countries are suffering more than ever from the consequences of flooding, others in arid and semi-arid regions are becoming drier by the day. Thanks to growing demands from agriculture, an expanding population, energy production and climate change, we inhabit a planet where water is increasingly in short supply. Examples of dramatic situations have been identified around the globe. From California to the Middle East, from North Africa to South Asia, groundwater reserves have diminished thanks to poor management and the results of inefficient irrigation, compounded by climate change, expanding conurbations and refugees seeking asylum from armed conflicts.

Water, as a result, is now a principal source of potential political, social and, even more dramatically, armed conflict. Water basins such as the Nile, Tigris-Euphrates, Mekong, Jordan, Indus, Brahmaputra and Amu Darya are just some of the areas which have been identified as potential crisis points, whilst a shortage of water will, if not remedied, lead to the poverty and social tensions provoked by a reduction in food production and energy supply. Such crises do not tend to lead to war between nations but rather to social confrontation between farmers and cities, between different ethnic groups and between those who reside upstream or downstream on the same river.

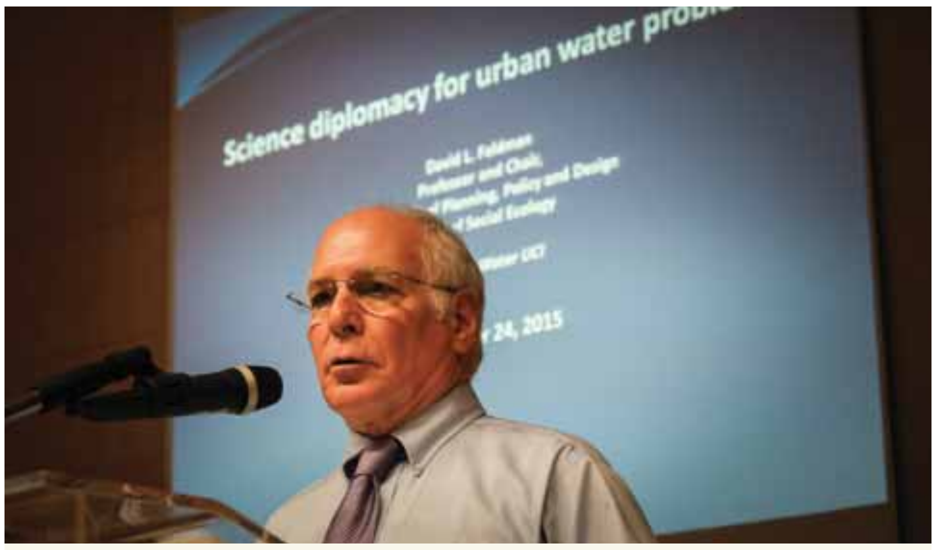
The primary answer to such potential challenges is to ensure that administrations improve the management of water and enforce the protection of their groundwater reserves. Collaboration (which between states already exists, exemplified by numerous treaties and bilateral agreements) is a further vital step. The Dubrovnik Declaration of Intent and the creation of the Dubrovnik Group is an example of a move in this direction, looking to convert water into a catalyst for Transfrontier cooperation between cities from diverse regions, each with their local idiosyncrasies and specific challenges, but capable of dialogue, the exchange of knowledge and experience coined by Dr Bernd Gawlik as 'Winning by Twinning' and the desire to join forces in creating a broad strategy that addresses the need for citizen engagement in the war on global water issues.



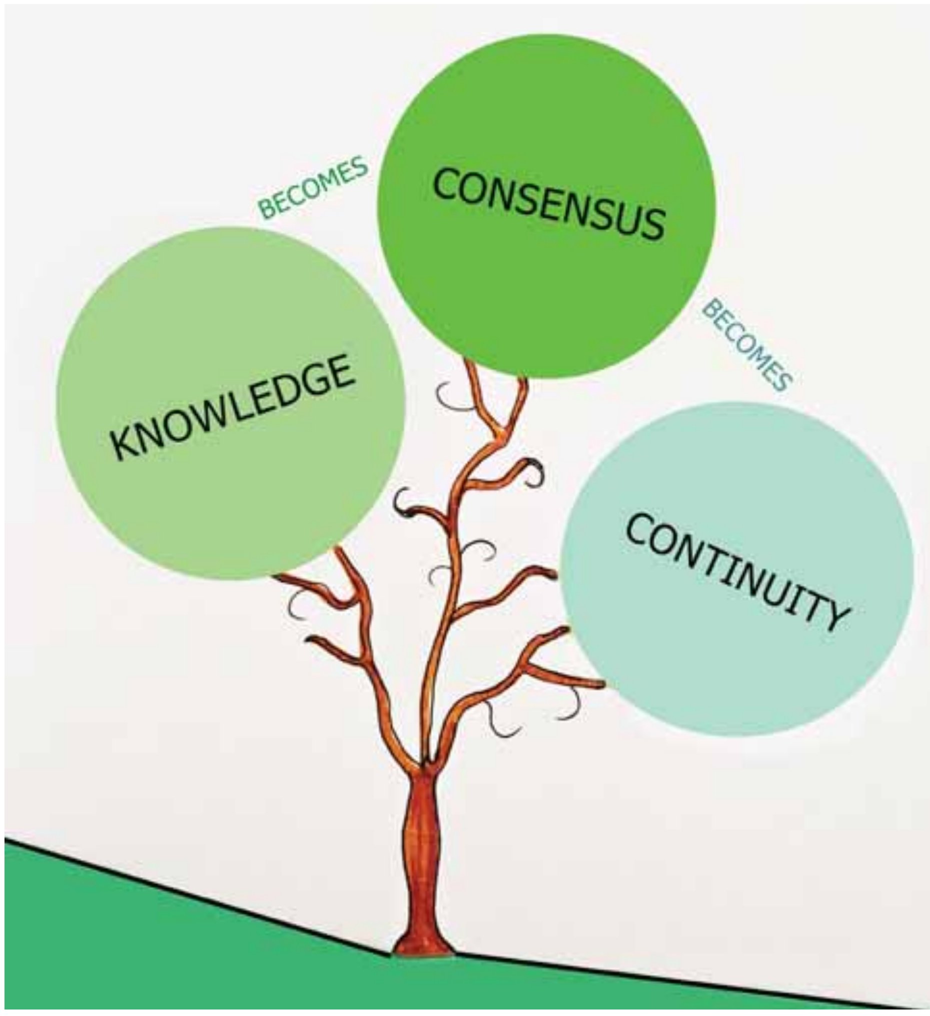
Aerial view of Dubrovnik old city. © RossHelen / Shutterstock.com

Since the initial moves made in 2015, municipalities and organisations from all over Europe, the Middle East and the USA have been invited to adhere to the Declaration and participate in the building of an alliance which has sought to become an effective instrument on the international stage of environmental policy. In order to establish a common base, the document was written as a declaration of intent which in no way has obliged the signatories to participate in any given specific action, so as to permit cities with funding problems and, in some cases, a historical mistrust of fellow signatories, to take a first demonstrable step towards working together without the pressure of a formal contract or project proposal. Towns and cities from Croatia, Serbia, Jordan, Israel, Palestine, Hungary, the United Kingdom, Turkey, Romania, Greece, Spain, Brazil, Italy, Germany, Sweden Bulgaria, the United States, Poland and Finland were involved directly or indirectly in the Dubrovnik Group and its activities, and the list of municipalities continues to increase.

The Dubrovnik Declaration of Intent has been instrumental in presenting to local politicians the need for cities and towns to convert supranational intentions into feasible regional and local realities, whilst benefitting from the advantages offered by an inter-municipal partnership based on trust and experience. Thanks to the Declaration, municipalities are starting to employ basic, cost-free methods such as the Science Café and School-Prize approach in order to make in a modest, yet practicable and effective manner, the initial moves in the creation of local stakeholder awareness and subsequent involvement.



David Feldman during the Dubrovnik conference. © Ricardo Rodrigues da Silva



Furthermore, the Dubrovnik Group has opened the door to a new concept described as SciArt Water Diplomacy. Born from a pilot scheme in Jordan which led to the exhibition **Science and Art in Water – Water through the eyes of Jordanian children** organised under the auspices of the Dubrovnik Group and led in Amman by Lina Aldasouqie, children attending schools in different countries were encouraged to consider the water problems facing their region and then describe their feelings through drawings.

Water has always been an element of great importance in the worlds of both science and art. It is the element that has dominated human civilisation throughout history. To observe it through the eyes of the artist means that we can perhaps come closer to the simple truth which one so often forgets; that water is life. This was clearly demonstrated in Amman. By creating thought-provoking, yet innocent images, Jordanian children were asking society to learn and work towards a more ecological, more sustainable and more peaceful future, perhaps far more effectively than any scientist could do. The dramatic results of this action led the Joint Research Centre, together with NETWERC H2O, the University of California and the members of the Dubrovnik Group to realise that here was a new and exciting way for science and art to bridge both traditional social borders and political constraints. This has led to a new route whereby in future years, the movement that was born on the Adriatic shore, in the rebuilt city of Dubrovnik (itself a haven for both artists and children), will explore to the full.

Core group of the Dubrovnik Group © Ricardo Rodrigues da Silva

THE DUBROVNIK DECLARATION OF INTENT

Having in the City of Dubrovnik on the 24th and 25th of September, 2015 attended a practical workshop in which new municipalities from Eastern Europe, Turkey, and the Middle East have provided input with regard to a practicable planning cycle at all political levels with regard to the issue of water and waste and having been encouraged to assess the current situation, and to support municipal integration and inter-municipal cooperation, stakeholder engagement and international networking linked by a common approach to raising people's participation in policies and choices on water and waste management whilst emphasising the dialogue between different levels of public administration and the different sectors engaged.

The signatories recognise that there exist challenges of urbanisation, water and climate change, resources, waste and the need for resource recovery and increasing costs of city infrastructures.

The signatories therefore affirm that:

i) Municipalities are centres of economic growth, employment, creativity, culture and innovation. Municipalities are producers, consumers, and sources of a host of global environmental problems.

ii) The initiatives to safeguard water resources often omit to underline the importance of municipalities, as the challenges and solutions regarding sustainable water use, energy and resource recovery will predominantly reside in cities.

iii) There exists a need to create adequate opportunities in order to ensure that our municipalities become the catalyst for improved urban management of our water resources.

iv) Municipalities can provide local solutions to global issues when they develop a coherent long-term integrated strategy and implementation plan on transport, energy, ICT, solid waste, climate adaptation (heat islands, urban flooding and water scarcity), water supply, wastewater treatment, air pollution and urban design.

v) People in urban environments need green and blue space, and healthy, attractive and liveable communities should become the long-term goal for municipal stakeholders.

And thus, the signatories state that:

The involvement of local stakeholders coordinated by municipal and regional administrations has resulted in a positive local influence on international issues whilst enhancing science and evidence-based decision-making in the field of water. This is the essence of the bottom-up approach. We, as a society, are faced with a series of challenges, including the increase of the global urban population, competing demands for scarce water resources, resource reduction, and the production of waste.

Hence the signatories, supported by the consortium of the BlueSCities Project funded by the EU Horizon 2020 programme, the members of the association NETWERC H2O, the Joint Research Centre of the European Commission and the members of the EIP Water Action Group, City Blueprints, will:

i) Seek to work together to implement and exchange experiences in order to provide answers to these challenges.

ii) Ensure improved exchange synergies between their respective municipalities and involve their respective local stakeholders, researchers and users, decision-makers and consumers, industry, SMEs and national and international authorities in said process.

iii) Establish the issues of water within the consciousness of citizens and city governors as a critical component fostering consensus in the participating municipalities in relation to water, with the aim of increasing international understanding and awareness at local/regional and national levels of best practices in urban water cycle services.

iv) Be informed of the process of the BlueSCities initiative.

And therefore the signatories declare their intent to:

a) Form part of a learning alliance and community of best practices for water between the municipalities present to be known as the DUBROVNIK GROUP.

b) Seek to implement at least one aspect of the citizen-engagement procedures which have been presented in the present workshop in their respective municipalities.

c) Present the first appraisal of this trans-municipal approach at a seminar in the year 2016.

Signed in (Name of the City), (Date: XX of XXXXXXXX, 2015)

ANNEX I

Non-municipal organisations present at the workshop and involved in the creation of the Dubrovnik Declaration of Intent and subsequent actions:

Joint Research Centre of the European Commission
Jordan SMEs
Fundació CTM Centre Tecnològic
Network for Water in European Regions and Cities – NETWERC H2O
University of California, Irvine
Hungarian Water Association
European Water Association – EWA
MIGAL
De Montfort University
Lund University
KWR
Easton Consultancy
Horizon 2020 Project: BlueSCities
European Innovation Partnership on Water

ANNEX II
SUGGESTED LOCAL ACTIONS.

Three local citizen engagement activities were established at the aforementioned workshop:
. Sciences Cafés
. School Prizes
. School experiments at local rivers.

The signatories of the Dubrovnik Declaration of Intent will receive detailed information concerning the organisation, dissemination and possible subsequent actions related to the three types of above mentioned activities.

The signatory cities are not obliged to undertake any of the aforementioned actions, but are encouraged to undertake one or more of them with the active support and expertise of the organisations listed in Annex I.

Science Cafés

A Science Café is an event that brings scientists and the public together in an informal setting such as a restaurant, pub or café. Science Cafés are being held all over the world and have many different formats. Some are lectures with audience-guided questions and answers, some have a moderated discussion between the scientist and the audience, and some focus more on round-table discussion. There is no right or wrong way to have a Science Café, and each organiser is free to design theirs based on their goals and their audience.

A main feature of a Science Café is that it is held in a public place other than in the host University or institution. Bringing a scientific discussion into an informal venue, such as a restaurant or a pub, is useful for making the audience feel comfortable about discussing the topic at hand and ask questions – it can be seen as much less threatening and there are fewer barriers between the public and the expert. Hosting the event in a restaurant is also a great way to reach new audiences that are not already involved in science. People who might not come to a lecture at a university are often more likely to attend one in a bar or café, and there is the added benefit of potentially drawing in people who are already at the venue socially.

Any water topic can be chosen, depending on the Science Café organiser's preference or speaker's expertise. Science Café organisers should also consider topics relevant to the local communities.

Prizes for Schools

School competitions will act as an additional medium – together with Science Cafés – to initiate citizen awareness within a municipality. The intention is that school pupils, aged between 7 and 12 years of age are presented with the issue of water and then encouraged to participate in a competition in which they draw what water suggests to them.

The intention is that the winners from each participating city will have their illustrations published in the City Blueprint Atlas, an important product of the BlueSCities project, published by the European Commission.

The competition structure is a crucial part of organising this kind of event. Participants will need to know when the competition begins and ends; which division of the school can participate; how resource use will be reported and, most importantly, how the winner is determined. It is important that everyone is on the same page and that all expectations and guidelines are established upfront.

The most important information to most student participants will be how to win. It is important to establish these rules upfront so no one is disappointed or feels cheated. While this is a competition, it is supposed to be fun and everyone should have a fair and equal chance of winning.

School experiments at local rivers

The idea is that, on a chosen day that is internationally symbolic for water, school children are taken to local rivers. Ten to twelve groups of students, as well as their parents, and academic staff from different countries, will be active in measuring the quality of the water and other ecological parameters around the river. They will then send it through the Internet to their colleagues and, with the academic staff participating in the exercise, they will analyse the data and discuss innovative ways of restoring the water quality. Lectures will be given the students and their families at workshops delivered by the academic staff, or the municipalities' authorities, and will be chosen on the basis of professional and intellectual merit, and willingness to fully volunteer. This activity will include a final task that the group/class should submit, and the teachers, the families and the academic staff will be present during the final event.

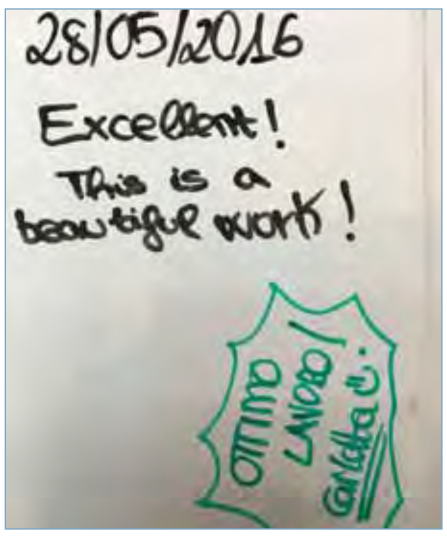
A more detailed description of all three suggested activities described above will be supplied to the cities who sign the Dubrovnik Declaration of Intent.

Applied SciArt
Water Diplomacy

Applied SciArt Water Diplomacy – the BlueSCitieS painting competition

While the mutual cross-fertilising effects between Science and Art have recently gained significantly importance in various centres of excellence such as the CERN, the Tate Gallery and the Joint Research Centre, the addition of a societal and political dimension has been neglected, not to say overlooked.

Unlike many other areas, water relates to many issues of conflict at international, regional but also local level. While the apparent dimension of what is commonly called "Water Diplomacy" is well understood at the international and regional levels and is the subject of a continuous process trying to accommodate national interests and water bodies, e.g. at the river-basin level, its importance for the municipal level is yet to be fully understood.

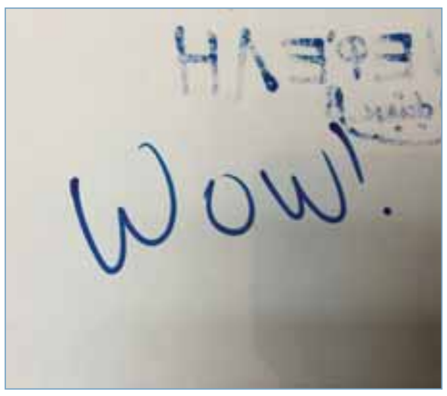


Art can convey complex principles related to water in a visually compelling way that connects imagination, emotion, and reason (the latter exemplified by science). At the same time, the arts – visual as well as performing – communicate these principles on a person-to-person, individual level. As a result, the role of the arts in disseminating powerful ideas and principles regarding water to diverse groups of people, and across national boundaries, may in some cases be more effective than that of more conventional forms of political communication. This can be conveyed through conventional diplomacy alone.

The cover of the Atlas features the winning contributions of a school painting competition organised within the context of the SciArt Water Diplomacy concept. Initiated by the Horizon 2020 BlueSCities Project and supported by the Network for Water in European Cities and Regions, school pupils in Spain, Turkey, Jordan, Israel, Romania and the United Kingdom illustrated how they perceive water.

They were inspired by the artwork of Ms Natalia Glowacka, an emerging young artist and scientist from Poland. First exhibited in Amman, Jordan, her illustration and interpretation of the water cycle has proved to be a catalyser for young people in becoming interested and actively involved in urban water management issues. The fact that Natalia is both a scientist and professional artist serves as an excellent example of how two completely different fields of expertise can join together to create a far more powerful joint effect.

During 2016, the competition involved primary school children from a vast range of social backgrounds; from those suffering the conditions of a refugee camp in Jordan to others who live in wealthy suburban areas of London. Besides the amazing creativity and awareness of these young minds, the competition highlighted the unifying power of water. It showed that we all live and see water in the same way, regardless of our nationality, culture or social status. This understanding sets the foundations for a new form of diplomacy, developed at the municipal level, between cities, towns and villages.



The Water Cycle Paintings

Natalia Głowacka, 2016
Częstochowa, Poland

The Water Cycle Paintings were created as a contribution to this Atlas with the aim of sparking the interest of children and inviting them to express their views and feelings on water.

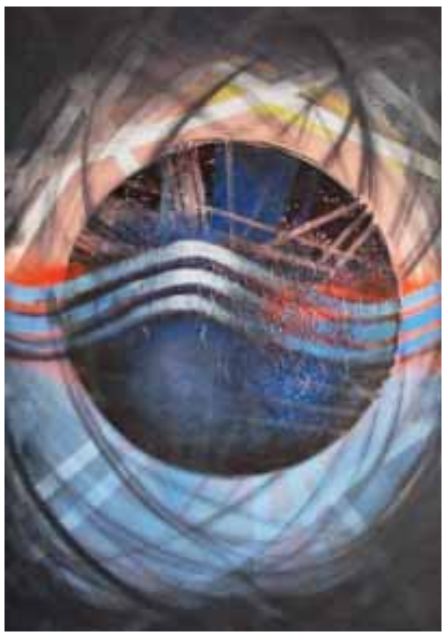
The Water Cycle Paintings address various dimensions of water: the political challenge, the aspects of fairness, the water-energy nexus, the connecting aspect of water and also its force as an element of nature, presented as a divine trinity of water, vapour and ice and hence a common element to the spiritual reality of mankind.

Water globally
(Woda globalnie)

80 x 80
Mixed techniques on canvas.

The painting addresses the global nature of water and illustrates the Earth as a "blue planet", in which the connectivity between individuals is based on the water cycle in a both physical and metaphysical way, thus leading to harmony and fluid common agreement of being human.

Water world
(Wodny Świat)



100 x 70
Mixed techniques on canvas.

"Water world" addresses the issue of water diplomacy and the need to negotiate and agree on a common and sustainable use of water. The wave form in the centre of the painting and the underlying glowing red focus on the water scarcity in the equatorial region of our planet, while the dark background reminds the observer of outer-space and the Earth being our spacecraft, where life crucially depends on water on Earth and energy received from the sun.

Water power
(Moc wody)

80 x 80
Mixed techniques on canvas.

The artist's interpretation of the immense power of water is expressed through the mystic form of a pyramid, which illustrates the different aspects of water in its molecular shape as H_2O. While in its uncontrolled way it leads to chaos and distruction, controlled water power also provides shelter and energy. Besides this two-dimensional way of looking at water it also addresses in a third dimension: the power of who controls water. These dimensions come together perfectly in the pyramidal shape.

Water bridges
(Wodne mosty)

100 x 70
Mixed techniques on canvas.

"Water bridges" is the most "political" of the Water Cycle Paintings. Bridges are needed to cross waters, but bridges are also needed to overcome water conflicts. The homage to the Roman aqueducts, reminding us of the masterpieces of engineering which we can still admire in the Pont du Gard, reflects on the essential role of water in the development of a civilisation. If we cannot build such bridges, our civilisation is doomed. The glowing red background reminds the observer of this menace.

Uncontrolled water
(Niekontrolowana woda)

100 x 70
Mixed techniques on canvas.

"Uncontrolled water" is a very personal and almost intimate interpretation of water, experienced in a pleasant and majestic way as a wave, but also in a distructive way as a vortex, which removes what is on the surface and reveals what is hidden.

Water variations
(Wodne wariacje)

100 x 70
Mixed techniques on canvas.

"Water variations" captures water's physical trinity as liquid, solid and gas, all coexisting in harmony while being completely different.
The painting is influenced by the artist's background as a scientist and engineer, using so-called phase diagrams to understand this mysterious trinity, which yet governs all processes of life on Earth.

Water energy
(Energia wody)

100 x 80
Mixed techniques on canvas.

The water-energy nexus is one of the interesting water challenges of the 21st century, as it describes the competition and interlinking ages between water and energy. Hydropower, water abstraction for cooling power plants, and the use of water in what is commonly called "fracking" are illustrated in this painting as hidden yet omnipresent aspects of water.

Applied SciArt
Water Diplomacy

Schools participating in the competition

. **AHLIYYAH SCHOOL for Girls,** Jabel, Amman

. **BARING PRIMARY SCHOOL,** London, Lewisham

. **ESCOLA FEDAC,** Súria

. **GÜVERCINTEPE Elementary School,** Başakşehir, Istanbul

. **MAHIS JORDAN Secondary School,** Amman

. **MEVASERET School,** Jerusalem

. **MIHAI VITEAZUL,** Sfântu Gheorghe

. **MOLWIAH School for Girls,** East Jerusalem

. **SZEKELY MIKO KOLLEGIUM,** Sfântu Gheorghe

. **SELAHADDIN EYYUBI IMAN HATIP Elementary School,** Başakşehir, Istanbul

. **UM ATTIAH AL ANSAREYAH School,** Al-Mafraq (Zaatari)

GENERAL RULES FOR SCHOOLS PARTICIPATING IN THE SCHOOL PRIZE COMPETITION

1) Children should be aged between 6 and 12.

2) Each participating school must be located within a city participating in the BlueSCities Horizon 2020 project or a city which has signed the Dubrovnik Declaration of Intent.

3) Only two schools from each city can participate.

4) Each participating school should choose one class of approximately 30 children who are within the specified age group*

5) The chosen class should receive a talk about the importance of water in their lives.

6) Each child is then invited to draw what water represents for him/her.

7) The drawings should be on paper size A3.

8) Any drawing/painting material is accepted.

9) The drawings should preferably be in colour, although this is not obligatory.

10) The drawings are collected by the teacher and then sent to the European Commission.

11) Drawings must arrive by post at the European Commission before February 29th, 2016.[1]

12) On 1 April, 2016 the winners of the prize will be announced and the decision communicated to the participants.

13) The First Prize is the publication of the winning drawing as the cover of the Urban Water Atlas for Europe of the European Commission. The winner will be invited with his/her parents to attend the presentation of the book in Brussels on a date to be decided.

14) Runners-up will have their drawings featured in a central section of the Urban Water Atlas for Europe of the European Commission.

15) Each participating school will receive a copy of the Urban Water Atlas for Europe of the European Commission.

*Alternatively, more children can be involved from different classes. The school teacher responsible should then choose the best 30 drawings to be sent to the European Commission.

1 The drawings should be placed in an appropriate package so as to avoid damage and be sent by registered post to the European Commission address which will be provided.

The winning paintings are:

. **AHLIYYAH SCHOOL for Girls,**
Jabel, Amman

1.) 2016_8-263
from **Dina Layth Alamoud**

2.) 2016_8-246
from **Jana Zabaneh**

3.) 2016_8-251
from **Sara Modonat**

SPECIAL Price - Most voted during JRC Exhibition

2016_8-274
from **Yasmine Nader Srouji**

. ESCOLA FEDAC,
Súria

1.) 2016_6-123
from **Bruna Cardosa Espluga**

2.) 2016_6-178
from **Oinhhoa Drez Draz**

3.) 2016_6-172
from **Noelice Entreva Uvoz**

. BARING PRIMARY SCHOOL,
London, Lewisham

2nd place overall | **MS CECHILO**

1.) 2016_3-36

2.) 2016_3-58
from **William**

3.) 2016_3-60
from **Zwchwy**

. GÜVERCINTEPE Elementary School,
Başakşehir, Istanbul

1st place overall | **Erol DIKMEN**

1.) 2016_10-346

2.) 2016_10-333
from **Melek Balci**

3.) 2016_10-342
from **Dilan Duran**

. MEVASERET School,
Jerusalem

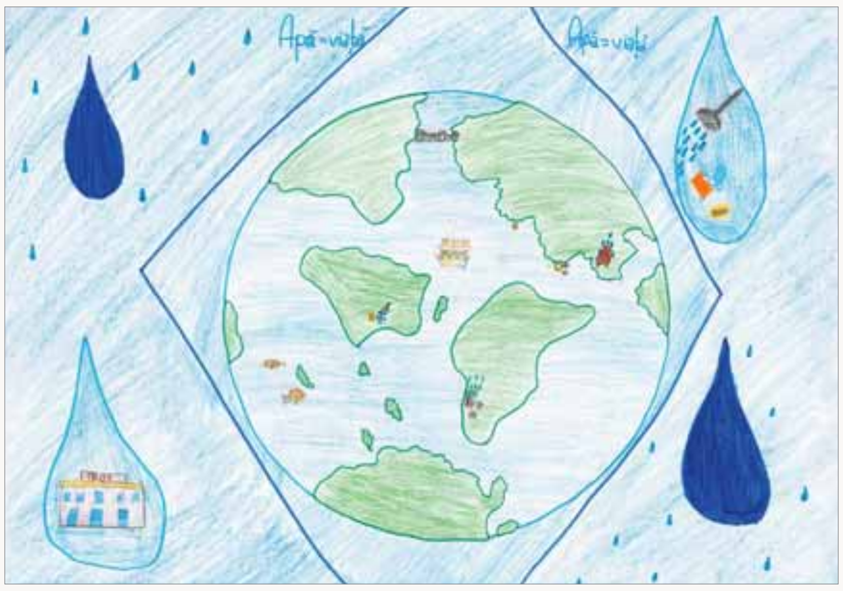
1.) 2016_5-109
from **Hadov Dahoki**

2.) 2016_5-108 from
Zohav Eeliya

3.) 2016_5-101 from
Sigal Dez

. MIHAI VITEAZUL,
Sfântu Gheorghe

1.) 2016_1-3 from
Bianca Diana Andaras



2.) 2016_1-1 from
Daria Acozmulesei

3.) 2016_1-4 from
Patrisia Beteringhe

. MAHIS JORDAN Secondary School,
Amman

1.) 2016_7-209
from **Rand Adwan**

2.) 2016_7-212 from
Maha Idal Awad Shnaikat

3.) 2016_7-190 from
Anonymous

. MOLWIAH School for Girls,
East Jerusalem

1.) 2016_4-80
from **Rabiha Jabir**

2.) 2016_4-62 from
Alaa Shwiki

3.) 2016_4-67 from
Einas Mahlous

. SELAHADDIN EYYUBI IMAN HATIP Elementary School,
Başakşehir, Istanbul

2rd place overall | **Aleyna YALIN**

1.) 2016_11-352

2.) 2016_11-358 from
Yusuf Can

3.) 2016_11-353 from
Zeynep Balci

. UM ATTIAH AL ANSAREYAH School,
Al-Mafraq (Zaatari)

1.) 2016_9-275
from **Rasha Ahmad Hneti**

2.) 2016_9-330 from
Narmeen

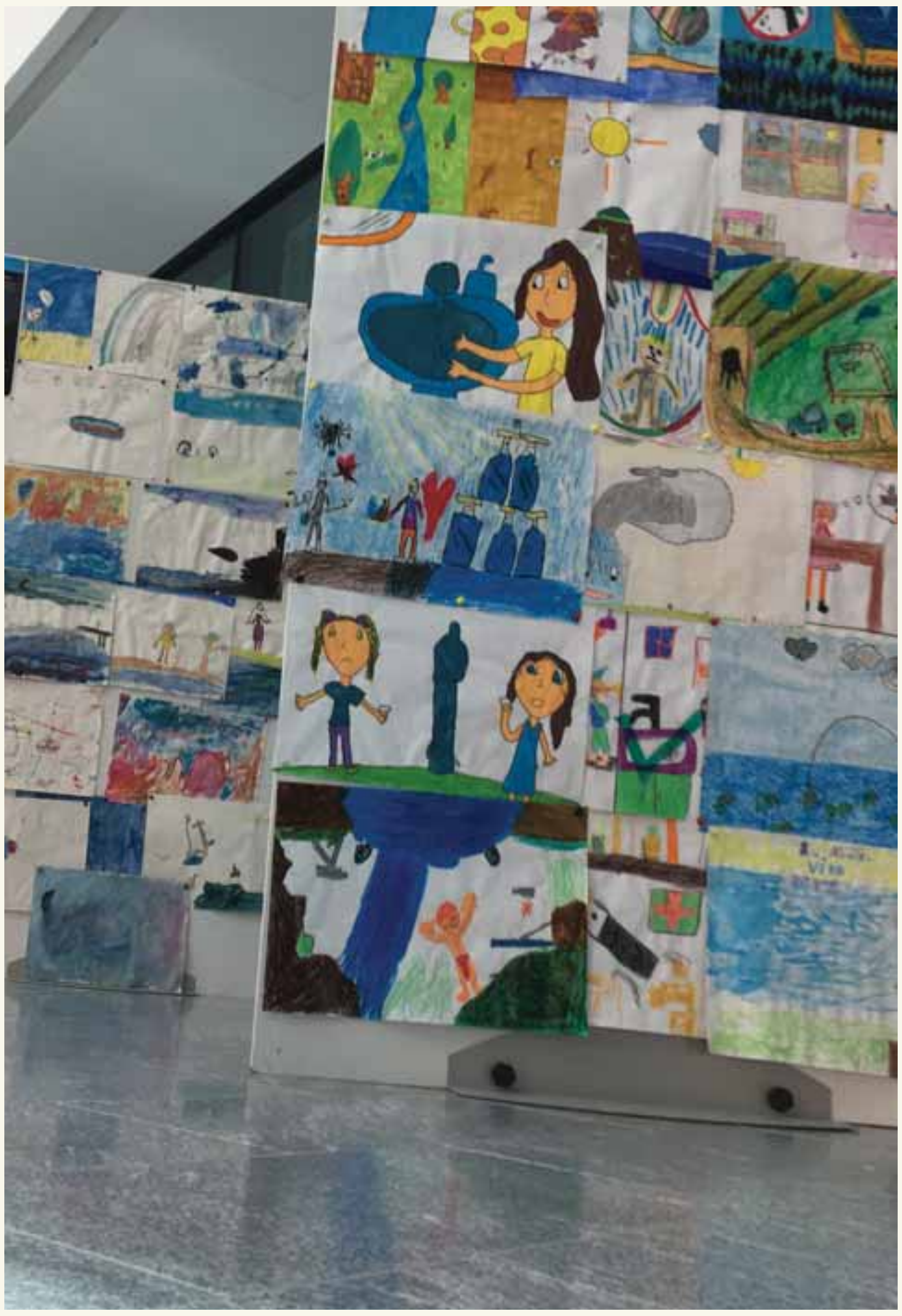
3.) 2016_9-321 from
Leen Mohammad

. SZEKELY MIKO KOLLEGIUM,
Sfântu Gheorghe

1.) 2016_2-24
from **Zsofia Damokos**

2.) 2016_2-19 from
Antonia Balagh

3.) 2016_2-30 from
Jimea Szdze



Emerging Heads
Water as a Profession

What role does water play from a professional perspective? Why do we choose to work with this topic?

What role does water play from a professional perspective? Why do we choose to work with this topic? The following interviews answer these questions from the perspective of young people, artists and scientists working with water. Water is a subject with plenty of different aspects and faces.

We learn from the interviews how water inspired young people to be interested in water and see, how it is an opportunity for personal development or professional career.

Ricardo R. SILVA, – Photographer and Graphic Designer

Q1: Ricardo, you are a professional photographer, but also a graphic designer. Talking about "water" what is the biggest challenge for you in dealing with it?

Ricardo: Not getting angry...! Water is a very big part of my professional and personal life. Being from a country that is mostly shoreline, all my life I have taken advantage of its recreational and life-sustaining abilities. It pains me to see how easily we take it for granted and how little we do to protect it. Professionally, mostly as a graphic designer, I believe the most difficult aspect is to summarise scientific information and translate it into laymen's terms. Water scarcity is probably our most important issue today, and it is critical to involve and "seduce" citizens to engage in this topic. In order to create awareness, one must find a emotional connection with the viewer, but doing so without over-simplifying the issue is a true challenge. As a photographer it is easier to create a reaction as water lends itself very well to photography. However, modern life has such a high turnover of imagery that it is difficult to create a lasting impression and consequently, meaningful change. I try to engage in projects that represent the human relationship with water and how easily we can lose this essential "tool". Hopefully this will lead to a more permanent shift in mentalities.

Q2: Can you tell us about "water, sciences and emotions"? How does the eye of the photographer sees this?

Ricardo: Water is a very "plastic" medium. As a photographer, it can make your day if you manage to capture all its abilities. Reflections, transparencies, and of course the playful nature of water. It is easy and fun to compose when water is available as content in your image. If you take advantage of water as a topic the possibilities are endless: a day at the beach, children playing in fountains, rainy days, or more serious topics such as water scarcity and contamination, energy use, among others. Water is such a constant presence in life that it is both a fantastically plastic and conceptual tool for the photographer. I believe it is vital to approach water sciences in a more engaging manner, one that brings the common citizen the awareness needed to help deal with the current issues. Photography, having such a powerful immediacy and global understanding, may truly be the perfect medium for such a goal.

A fisherman walks on the beach in Vieira de Leiria. Portugal, 2011 © Ricardo R. da Silva for Público Newspaper

Q3: What would be the best photo of water ever? What would be your personal criteria in selecting it, and what was your best composition of a photography related to water?

Ricardo: That is a very tough question. The first image that came to mind was Henry Cartier-Bresson's image of a man leaping over a puddle. Granted, it is not an image OF water, but it is a perfect representation of its constant presence in our lives and how we engage with it. From a photographer's point of view, the composition is brilliant, and it is the image that came to represent "the defining moment". From my own images I particularly like one I took in Vieira de Leiria. I was doing a story on reducing coastlines. Vieira de Leiria is a small fishing village and the community and the beach are interdependent. The bigger, more touristic city of Figueira da Foz, 20 kilometres north, uses sand from the bottom of the sea from the surrounding coastline to fight rising sea levels and damaging winter tides. This ruined the sand banks that protect smaller beaches like Vieira de Leiria and have driven them close to extinction. I believe the image of a single man engulfed by the rising tide says it all.

Anna STRZELICKA, – Scientist

Q1: Anna, how did a young Polish scientist end up in the UK to work on the urban environment?

Anna: It was a combination of having the right people in my life at the right time and being able to recognise the opportunities available for my own personal development. I am fortunate to have incredibly supportive parents who have always encouraged me to achieve my maximum potential. My closest friend Katarzyna was also a huge inspiration, thanks to her I learnt to write and speak fluent English which in turn opened many doors for me. Prof. Andrzej Górak from the Technische Universität Dortmund had the biggest impact on my academic career. He helped me focus my professional development by encouraging me to make some bold choices, specifically starting my PhD research with the Water Software Systems Group at De Montfort University in Leicester. I began working on resource efficiency and sustainable development of households and communities and continue to research the impact on the urban environment.

Q2: In the past two years you have been working on water and waste management in cities. In this regard, are our cities smart enough when it comes to water and waste management?

Anna: Unfortunately, there are still a vast amount of improvements to be made. However, some cities are on the right track. In my opinion a more integral and adaptive approach is required. When considering water and waste management, cities and their inhabitants should also take into account the environmental impact and connection to food, energy, transport and ICT. If all interactions between these aspects are identified and acknowledged, cities have a better possibility of becoming truly smart. From my experience, people don't seem to realise how much water is needed to bring food to their homes or how much energy is required to transport and process their waste. The list of examples is endless. It is essential to educate people from an early age in order to raise proper awareness of the environmental challenges we are currently facing in the world. We also need young people to be interested and involved in work that specifically addresses these challenges. Additionally, it would be smarter if cities learned from one another, sharing good solutions to problems and adapting these where applicable. I believe this would greatly improve water and waste management practices.

Q3: Europe is changing and our cities, too. What do you expect for your own professional development? Will you continue to work on aspects of greener and more resilient cities?

Anna: I hope to continue my research on the urban environment as I myself live in a city as does the majority of the population. My intention is to work with cities to improve their sustainability in the modern world. It would be immensely rewarding to know that my work could contribute to their improvement, even if only slightly. There is a lot of potential to change the way cities operate and the mind-set of people living and working within them. I would like to include the latter in my research as I believe that citizen engagement plays a fundamental role in creating a sustainable environment. There are many technological advancements available as well as emerging solutions that could be introduced within cities. However, if we want to see cities become greener and more resilient, it requires better educational programs for people in order to influence positive changes and increased environmental consciousness. I remain optimistic and will continue to utilise my knowledge and passion to help influence and shape a more sustainable future.

Emerging Heads
Water as a Profession

Stef Koop,
–
Scientist

Q1: Stef, you decided to go for a professional career related to water? Can you explain how you came to this decision?

Stef: My motivations are mainly related to my personal sense of urgency regarding climate change mitigation and adaptation. Water and climate change are tightly interlinked we face huge challenges now and will face even more in the near future. I want to do my part and contribute to solutions that make our lives and those of future generations more sustainable and liveable. I do this every day by reducing my greenhouse gas emissions, for example by refusing to buy a car and getting around by. In my work, I am involved in assessing the sustainability of urban water systems and their governance. We find that technology is often not the main limitation, the awareness and willingness to act amongst citizens and decision-makers is much more important. It is fascinating how organisations and governments work. I am still very much surprised by the enormous possibilities that there are to improve climate readiness by improving water governance and management systems. So, it is a highly interesting job, in which you can make an important contribution to a more sustainable future.

Q2: For sure, you love the topic, but what is your personal dream you would like to realise with your work on water?

Stef: I am working hard to contribute to more sustainable water systems. At our research institute, we are busy with resource recovery from wastewater, exploring water efficiency gains and finding more robust ways of producing drinking water, etc. Exciting things are starting to happen and will prove to be very important over the coming decades. The EU, national and local governments as well as business, insurance companies and, last but not least, civilians are becoming increasingly aware of the water-related risks and see the benefits of smart water management. At present we are very busy developing tools to enhance integrated long-term planning in cities and help them become proactive instead of only reacting to hazards as they occur. It will save us billions of euros and will contribute to our quality of life. Developing these tools is interesting, but my real dream is that they will be applied as much as possible to facilitate sustainable decisions and solutions.

Q3: ... and to achieve this, what are the biggest challenges you have to face?

Stef: To convince civilians, governments and companies to think about the impacts and risks of flooding, water scarcity, urban heat islands and water pollution, now and in the future. That it is important to develop long-term plans, take into account risks and uncertainties, and look for win-win solutions by cooperating and combining different goals and sectors. It is simply better for your wallet and for the world that your children are going to live in. Although highly important, this message is often not something that impacts people directly and often requires new approaches. Unfortunately, most organisations have a reluctant attitude towards change. In order to convince them, I need to work hard and develop many skills and be persistent. You need to be a good scientist, a good business person and understand the political processes that lead to the acceptance of sustainable measures.

Natalia Głowacka,
–
Artist and Scientist

Q1: Why did you decide to work on this topic "Water in cities"?

Natalia: Water covers most of the area of our planet, for us it is very easy to think that it always will be abundant. At the current rate of water consumption, the near future may bring the problem of water shortage. Water affects every aspect of our lives. It has already become a highly valuable resource. Water access in developing countries is still problematic. People start to realise that water scarcity is a problem, and one , we should be aware of. We should raise awareness starting with the young generation, who may experience water scarcity in the future. The starting point is to organise social events to underline the main global issues. Propagating ''Water Citizenship'' among social communities brings advantages especially for young people, helping them to become more aware of the contemporary problems.

Firstly, we have to learn what is the source of problem and, in particular, we cannot forget that water changes everything. Water is our life.

Q2: Natalia, you are both a scientist and an artist – Can you tell us what attracts you in the topic of water as a scientist?

Natalia: Our lives begin in an aqueous environment. Water provides a safe environment for the developing organism, ensures the freedom of movement, protects against too much stimulation from the outside world. Water is involved in all systems of all living creatures. Our blood and our tears, all come from water. From a chemical point of view, we can consider the issue of water from many perspectives. Among all molecules, water is one of the most unique, which is perfectly known to man. It is one of the most important molecules to our biological systems. Water is a crucial component of the human body, it regulates body temperature, and, keeps our skin soft and our organs hydrated. Water is the main constituent of bodies' cells. However, there are still many questions to be answered, about the importance of this most significant element of our body and our everyday diets.

Q3: ... and as an artist?

Natalia: Water. Majestic beauty. The topic of water is very inspiring. The process of capturing and painting water is quite complicated. One of the most beautiful and magical elements in the art of water is light, which passes through and creates the reflection of water. From the artistic point of view, capturing water is not easy at all, due to its irregular structure and unpredictable behaviour. To achieve the desired effect, I need to deal with sparkles, reflections and light to capture and paint the colour, flow and rhythm of water. Forms and shapes which can be created by water are countless. Water is mysterious, wild and uncontrolled. At first, water seems to be transparent, but this is the lying first impression. In fact, we can identify the wide colour scale, in the movement of the surface of water. The experience of water develops new artistic expressions. Returning to our initial experiences of being in water, feeling the softness and warmth of water, brings a sense of security, which we instinctively feel since the time spent in our mother's womb. This feeling touches each human being. Instinctively, we remember where we came from.

Netwerc H2O

Created in 2012 by the Fundació CTM Centre Tecnològic, the Network for Water in European Regions and Cities (NETWERC H2O) which at present has over 500 members under the Presidency of the City of Pisa, was founded in order to provide the municipalities and regions of Europe with a voice in the forum of water issues at a supranational level, both in Europe and beyond. Despite being identified by the majority of the lead in international organisations such as the United Nations, the Organisation for Economic Cooperation and Development and the European Union itself as key figures in the move towards an environmentally sustainable society, municipalities (or cities as they tend to be generically named) have historically had little or no say in the ongoing dialogue concerning international water affairs.

NETWERC H2O sought from the very beginning to address this anomaly as well as to provide a clearer and more effective channel of communication at the service of all supranational institutions which have the need to interact, cooperate and implement strategies in collaboration with local authorities. The same local administrations are recognised as the most important interlocutors with the citizen, and are thus essential actors in the creation of the public awareness, social consensus and political continuity necessary in order to ensure that long-term water policies may achieve their full potential.

NETWERC H2O has also demonstrated in the past four years the importance of city-to-city learning and a capacity at a local level to address interregional diplomatic issues in an effective, low key manner, permitting the execution of actions which can be described as examples of science diplomacy.

It is true that NETWERC H2O has and will continue to involve cities, directly or indirectly in publically funded projects, proposals and initiatives but, above all, the organisation's mission is to guide municipalities who have both practical and economic problems related to water by enabling their communication with those entities, be they funding organisations, technical experts or politically conscious communicators, who can aid them and advance their cause.

The information which NETWERC H2O seeks to divulge comes from both regular and ad hoc sources. The organisation, as the result of a number of bilateral and multilateral agreements, has direct access to numerous official sources of information which can be transferred to the local government sector. Similarly, local governments are able to initiate bottom-up dialogues with international agencies through the established channels of the association.

NETWERC H2O promotes the vision of improved and more frequent direct democracy within the water sector. It is the ideal instrument to permit direct access to those stakeholders who are expected to convert policy into reality and white papers into confirmed results. Similarly, cities, towns and villages of all sizes receive information, professional assessment (as illustrated by the BlueSCities methodology (www.bluescities.eu) and city-to-city exchange described as "Winning by Twinning".

The necessity for NETWERC H2O to be further developed is evident. Under the banner 'The Local Response to the International Issue of Water', it has already been responsible for championing municipalities as key players in addressing the most important challenge of the 21st Century. This is the role which it will extend in the coming years.

Making cities smarter
The BlueSCities Project

The BLUESCITIES Project

The project Blueprints for Smart Cities (BlueSCities) aims to develop the methodology for a coordinated approach to the integration of the water and waste sectors within the 'Smart Cities and Communities' European Innovation Partnership. It identifies synergies in accordance with Smart City ideology, and compliments other priority areas such as energy, transport and ICT. It seeks to contribute to the achievement of the EU's 20/20/20 objectives.

Smart cities can provide local solutions to global issues, when cities develop a long-term integrated strategy and implementation plan on transport, energy, ICT, solid waste, climate adaptation (heat islands, urban flooding and water scarcity), water supply and wastewater treatment. There have been excellent actions where the involvement of local stakeholders, coordinated by municipal and regional administrations, has resulted in a positive local influence on international issues whilst enhancing science and evidence-based decision-making in the field of water. This is the essence of the bottom-up approach. We, as a society are faced with a series of challenges including the increase of the global urban population, competing demands for scarce water resources, resource reduction, and the production of solid waste. In order to provide answers to these crises, and building on the hitherto successful implementation of the European Innovation Partnership (EIP) Water Action Group: CITY BLUEPRINTS, the BlueSCities Project aims to:

- Focus on the need to integrate water and waste into the smart city approach, as defined by the SIP for Smart Cities and Communities.
- Ensure improved exchange synergies between researchers and users, decision-makers and consumers, industry, SMEs and national and international authorities.
- Put to practical purpose the CITY BLUEPRINTS project, whereby a baseline assessment of the sustainability of water management in a city is produced providing the data required for a practicable planning cycle at all political levels.
- Assess the current situation, produce case studies of four chosen cities, provide tools for integration and implementation, stakeholder engagement and international networking whilst emphasising the dialogue between different levels of public administration and the different sectors engaged directly or indirectly in the EIP Smart Cities and Communities.
- Produce a Blue City Atlas and a self-assessment baseline assessment tool for water and waste in cities in order to enhance the implementation of European Smart City activities.
- Provide data and formulate sufficient recommendations in order to produce a practical guidance document which will be developed and distributed to relevant stakeholders, emphasising how to support integration between water and waste within the concepts of the Smart Cities SIP.
- Provide recommendations for further research and technological work in a complementary publication and organise practical training courses which will be employed to further demonstrate the need to involve strategic sectors at distinct European political levels.
- To establish the issues of water and waste within the consciousness of citizens and city governors as a critical Smart City component, fostering consensus in the participating cities on developing further the policy orientation of the project, likely to influence the Smart Cities agenda in the years to come in relation to water and waste.

Impacts on current Commission initiatives

BlueSCities will promote European regulatory innovation and solutions to other strategic partners and countries. In light of the ever increasing importance of water resources for the economic well-being of our cities and the pivotal role of European water know-how, it is vital for Europe to be actively involved in establishing close links to cities in emerging economic areas. This will give Europe an opportunity to influence the design of future city infrastructures that will affect the lives of every person in the world. It will also give European companies an excellent framework within which they may offer products and services. BlueSCities aims to have a profound and lasting impact on overcoming the barriers to a more widespread implementation of the objectives of both the EIP on Smart Cities and the EIP Water. The project is perfectly aligned to effectively support the Europe 2020 Flagship initiative on Innovation Union, to contribute to Smart Cities and Communities as well as the Flagship initiative on Resource Efficiency Europe, and to effectively contribute to the European Innovation Partnership (EIP) on Water. BlueSCities will have a strong impact on technological, academic, economic, environmental and, above all, social dimensions. BlueSCities will ensure increased market opportunities for the water-related industry, specifically SMEs, which will, in turn, promote innovation, growth and job creation in cities.

BlueSCities contributes to the Commission's initiative on "Smart Cities and Communities"

Cities are becoming more and more of a focal point for our economies and societies, particularly because of on-going urbanisation, and the trend towards increasingly knowledge- intensive economies as well as their growing share of resource consumption and emissions. To meet public policy objectives under these circumstances, cities need to change and develop, but in times of tight budgets this change needs to be achieved in a smart way: our cities need to become 'smart cities'. The European Innovation Partnership on Smart Cities & Communities seeks to significantly accelerate the industrial-scale roll-out of smart city solutions, integrating technologies from energy, transport and Information and Communication Technologies (ICT). The overriding goal has hence been formulated as follows: "This partnership strives at a triple bottom line gain for Europe: a significant improvement of citizens' quality of life, an increased competitiveness of Europe's industry and innovative SMEs together with a strong contribution to sustainability and the EU's 20/20/20 energy and climate targets. This will be achieved through the wide-reaching roll out of integrated, scalable, sustainable Smart City solutions – specifically in areas where energy production, distribution and use; mobility and transport; and information and communication technologies are intimately linked." BlueSCities contributes to the implementation of a broader, and more integrative approach to 'smartening up' Europe's cities by linking energy, transport and ICT with water, wastewater, solid waste, blue and green spaces and, last but not least, people.

The nucleus of our project is guidance on good governance in the areas of water and waste within an integrated Smart or Intelligent City approach. As such, the basis of our work lies in a statement made by Commissioner Hahn: "Technology is important to implement an intelligent city concept, to create new business opportunities, to attract investments and to generate employment. But technology alone would not bring about any wonders. Good governance and the active involvement of citizens in the development of new organisation models for a new generation of services and a greener and healthier lifestyle are also important." In addition to innovative solutions, the Strategic Implementation Plan and the BlueSCities proposal will create added value for Europe by helping to align existing city initiatives and projects, helping to create economies of scale and more effective knowledge sharing. BlueSCities will ultimately establish strategic partnerships between industry, innovative SMEs, European cities and, above all, European agencies in order to guarantee the long-term fulfilment of the European Urban Agenda 2050, which will include the initiation and implementation of policies at all administrative levels, including cities.

BlueSCities contributes to the aims of the EU EIP on Water

The EIP on Water was established to speed up the development of water innovation, contribute to sustainable growth and employment, and stimulate the uptake of water innovations by the market and society. The outcomes of BlueSCities are perfectly aligned with the aims of the EIP on Water, in that the implementation of smart governance in cities will have a profound impact on the water technology and waste market, while the non-technological innovations will impact positively on society and the environment with regard to sustainable solutions for water and waste. The EIP on Water has listed eight priorities which centre on challenges and opportunities in the water sector, and on innovation-driven actions that will deliver the highest impact. Five thematic priorities have been selected: (1) Water reuse and recycling, (2) Water and wastewater treatment, including recovery of resources, (3) Water-energy nexus, (4) Flood and drought risk management, and (5) Ecosystem services. In addition, selected cross-cutting priorities are (6) Water governance, (7) Decision support systems and monitoring, and (8) Financing for innovation. The current City Blueprint Action under the EIP Water and, in particular, our BlueSCities approach, links the priorities on water to the EIP on Smart Cities in the areas of water, wastewater, energy and solid waste.

BlueSCities addresses the implementation of the Europe 2020 Flagship Initiative on Innovation Union

The implementation of the innovation union calls for a number of actions to be taken to make the European Union more innovative and therefore competitive, while tackling a number of societal challenges. BlueSCities will specifically impact on the implementation of smart governance through the main aims of the project, which are a) to provide guidance to implement a number of technical and non-technical innovations, based on previous research, that will overcome the barriers to sustainable approaches for water, wastewater and solid waste management, which currently shows fragmentation across Europe, and b) to develop a number of practical methods in order to achieve these goals.

Further impacts of the Blueprints for Smart Cities project

1. An increase of European understanding and awareness at local/regional and national level of best practices in urban water-cycle services and waste management procedures.

2. The creation of a learning alliance and community of best practices, thus shortening the innovation value change and market uptake of innovative water and waste management and treatment technologies.

3. Assistance for small and medium-sized enterprises (SMEs) working on water and waste-related eco-industries to enter new markets in other local communities, for instance on initiatives to implement the circular economy concept. In a recent report of the Ellen MacArthur Foundation (EMF, 2014) an economic and business rationale for an accelerated transition towards the circular economy was described with impressive cost savings for Europe: "In the quest for a substantial improvement in resource performance across the economy, businesses have started to explore ways to reuse products or their components and restore more of their precious material, energy and labour inputs. The time is right, many argue, to take this concept of a 'circular economy' one step further, to analyse its promise for businesses and economies, and to prepare the ground for its adoption".

4. The economic gain from materials savings alone is estimated at over a trillion US dollars a year. A shift to innovative reusing, remanufacturing and recycling products could lead to significant job creation. 1 000 000 jobs have been created by the recycling industry in the EU alone (EMF, 2014)

CONCLUSIONS, OUTLOOK AND PERSPECTIVES

Water variations
(Wodne wariacje)
Natalia Głowacka, 2016
Częstochowa, Poland

100 x 70
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas

Conclusions

1. The Urban Water Atlas for Europe is an accessible communication tool

The Urban Water Atlas for Europe is intended to inspire the general public's interest and participation in water issues, combining not only the efforts of scientists, researchers, artists, politicians and municipal stakeholders, but also children and their teachers in a new, accessible approach.
The Atlas describes the current water management status in a selection of European cities, which, despite their many differences, recognise that learning from each other can generate local solutions for global water challenges.
This Atlas hopefully will act as a catalyst so that more and more municipalities will revise their water management approach, not only for their own benefit, but as part of a broader, cooperative movement towards a more sustainable global community.

2. 'Winning by Twinning' provides a route to success

Europe has a long tradition of inter-municipal cooperation, more necessary today than ever. Urban areas which have been in the vanguard of the development and implementation of environmental policies have a vital role to play as leading examples to more sceptical or less experienced counterparts.
A single municipality benefits from the support and mutual collaboration of others, with no single community having all the answers to its problems. The combined learning of different communities can guarantee access to tried and tested methods to achieve sustainable urban water cycle services.

3. Cities must be environmentally responsible

Many of the environmental problems we face are born in our cities, but that is exactly where the solutions must be found and applied. There is a steady trend of migration away from rural areas, with the result that approximately 75% of Europeans now live in urban areas. This process of urbanisation, together with changing consumer patterns, land development and environmental factors, negatively affect natural resources such as water, energy and nutrients for food, and also have an impact on economic development and human well-being.
Therefore, all urban communities have a responsibility to combat the negative effects of such things as aging water/wastewater infrastructure and poor solid waste management. Failure to act can increase the problems of flooding, water scarcity, water pollution and adverse health effects for which the costs of response and rehabilitation would be enormous.
Cities must create all-encompassing strategies which incorporate water and waste, with energy and transport and ICT (information and communication technology) as part of an holistic Smart City approach. This must take into account the interests of all stakeholders within a clearly defined and transparent governance structure.

4. Actions at municipal level and with citizen engagement are fundamental

National and international institutions are effective at identifying the broad global trends to be addressed. But it is municipalities who must lead the implementation of policies and practical actions whilst engaging the citizen.
The municipality is the level at which administrations can interact most effectively with citizens and ensure they are informed. An informed citizen has greater interest and is better able to express any concerns. If their concerns are not alleviated, this may provoke fear. Knowledge must therefore be accessible in order to ensure that citizens together are capable of creating an informed social and political consensus (as opposed to a popular consensus based on ignorance), without which even the most ambitious political, economic and social measures are doomed to failure. Many of the aspects of a successful urban transition require time and money. The citizen is an individual unit which, when multiplied, becomes public opinion. Public opinion becomes votes and votes are converted into executive power, which is in turn accountable to the general public. Active civic participation at the municipal level in alliance with technical expertise, becomes the foundation stone of a new, environmentally sustainable community.

5. Inter-sector collaboration is key to creating sustainable communities

Each sector has its dedicated specialists and experts vital to its success and to that of the community it serves. However, a such a focus often becomes an obstacle to creating a truly holistic approach to the situations which require the input and cooperation of multiple sectors.
Cities require a long-term framing of the challenges they face within a proactive and coherent urban agenda in order to maximise the co-benefits and to minimise their costs. Just as cities must exchange their knowledge and experience, so too must the distinct experts pool their collective wisdom, working together to identify the common causes and solutions required. The nexus of energy, transport, ICT, water, wastewater, solid waste, ecosystem services and climate adaption must be approached as a cohesive whole leading to the implementation of improved governance, an effective circular economy and social innovation. Water has been taken for granted when compared to energy, transport and ICT. Water is the missing link within the concept of a resilient city that must efficiently manage its available resources, be resilient to extreme weather events, and maintain a clean, healthy and attractive environment.

6. Clear communication is critical to citizen awareness and engagement

Both citizen engagement and inter-sector collaboration depend on the availability of transparent, dependable information upon which all acceptable decisions must be based. From the outset, a benchmark must be established upon which all future results can be correctly evaluated. Data must be sufficiently detailed to be of use to the informed reader, but also sufficiently simple to be accessible to public opinion.
The urban water footprint, the infographic on water demand & availability, flood risks and drought status, the City Blueprint® and the City Amberprint (the latter two developed through the European Innovation Partnership on Water and the Horizon 2020 project, BlueSCities) provide examples of good communication mechanisms. By the clear illustration of relevant indicators, these tools permit cities to evaluate their performance in the areas of water use, water and wastewater management, water quality, climate robustness and governance (City Blueprint®) and in the areas of energy, transport and ICT (City Amberprint). These communication tools can be understood by anyone interested in the issues and serve not only as a technical aid, but also as a means to promote public awareness. Combined with more detailed analyses of the indicators, an administration can initiate the process of identifying objectives, developing strategies approving policies, and implementing actions to create a more sustainable and resilient city.

7. Sustainable cities depend on full integration of water within a multi-disciplinary approach

Access to sufficient amounts of clean water is one of the principal issues the world faces. Humans prospered for thousands of years without electricity, motorised transport and many other examples of what we now consider to be basic ingredients of our existence. But without water, there is no life. Europe in general enjoys an ample supply of water, but forms part of a global reality which if not addressed now may

lead to the most catastrophic of scenarios in a not-so-distant future. Climate change, land use modifications and demographic evolution have already demonstrated their devastating results. Whilst Europe has witnessed damaging floods and water scarcity in some regions, other regions in the world have faced severe drought and famine.
Europe has an important role in the mitigation of the threats to our planet. In the same way, every city and municipality must recognise its own contribution to the problems whilst assuming a responsibility to promote a more sustainable global environment. The way forward is through successful urban governance combined with stakeholder awareness and participation, and systematic collaboration between cities of all regions. We cannot afford to ignore the evidence any more. The future need not be bleak. Water, potentially a contributor to interregional conflicts and migration on an unimaginable scale, could prove to be one of the elements for peace and stable communities through mutual knowledge exchange and support. The concept of Science Diplomacy is a powerful one, uniting the politician, the diplomat, the scientist and the technician in a common cause, reducing interregional tensions and avoiding potential armed conflicts. Indeed, there is no one who cannot or should not be involved in this most noble of enterprises.
The relationship between science and policy is an old one, and often closely related to the world of culture, which in turn serves as a neutral element capable of reinforcing coalition. It is no coincidence that the Urban Water Atlas for Europe has been created not only by scientists and researchers, but also artists, politicians, municipal stakeholders, and children who have provided the power of their imaginations to produce many of the illustrations in this book.
A new approach is possible.

Outlook and Perspectives

Water and the Urban Agenda for the EU

Through the Urban Agenda for the EU, national governments, European institutions and other stakeholders will work together for a sustainable, innovative and economically powerful Europe that enables a good quality of life for its citizens.
The additional international research compiled in this Atlas reveals that water in cities is of huge importance to Europe and beyond. While much has been said on 'cities being smart', we understand today that this is not enough. Our cities must also be resilient and ready to address the challenges we face.

This requires that cities apply long-term framing, thinking and planning regarding their infrastructures and use of urban space. The benefits, from both an economic and societal perspective, are huge. This has a cost, but costs would be much larger if no actions are taken.
What is needed are actions on social innovation, novel approaches for governance and a thinking of 'closing the loop' through greater recycling and re-use, thus bringing benefits for both the environment and the economy.
It is the challenge of future urban living to embrace opportunities that arrive from such proactive and long-term approaches of circular economy and blue-green infrastructures as demonstrated in this Atlas. Water is the connecting link.

Citizens require smart goals

The translation of complex and often technology-based solutions for improved urban water management to understandable and acceptable political measures, is paramount for success. Therefore, it is necessary to formulate the long-term objectives of a sustainable city as S.M.A.R.T:
Specific: set specific targets to reach long-term goals,
Measurable: use indicators to monitor progress,
Assignable: specify who is accountable and/or responsible,
Realistic: set realistic goals that can be achieved with available resources,
Time-related: specify realistic and meaningful time scales.

The indicators used in this Atlas, such as the City Blueprint®, City Amberprint and Water Footprint allow cities to quickly benchmark their own performance. The use of such infographics is valuable to engage with citizens, monitor progress and communicate improvements.
There is a need for a uniform and reproducible baseline assessment of the performance of cities in the areas of water, waste and climate resilience. The same applies to other areas such as energy, transport and ICT. It must be carried out on a scientific basis and can be seen as the start of a longer process in which concrete and tangible actions are implemented and regularly benchmarked with, for example, the City Blueprint® approach and other mechanisms.

The sense of urgency

The time window to implement a more resilient and wiser city approach is narrow and rapidly closing. The longer we wait, the more expensive adaptation will become and the greater the risks to citizens, the economy, and also to the role of cities as our primary living and working environment. Water is key to a sustainable city. There should be simultaneous action that links infrastructures, institutions, and information together. The UN Sustainable Development Goals on cities (SDG 11) and water (SDG 6) emphasise the urgency and importance of acting now.
Particularly at risk are cities in transitional and developing countries at the borders of Europe, where the pressures of urbanisation, increasing demand for natural resources, climate and limited financial resources lead to immense challenges that threaten the quality of life of current and future generations.

CLOSING REMARKS

The world's population is set to increase by a further 30% between now and 2050, while its **resources** and the sustainable capacity of its **ecosystems** will remain finite. Maintaining **economic growth** and **human well-being** in the long term therefore requires that we move our model of socio-economic development away from the relentlessly growing use of resources towards one that alleviates the enormous burden placed on the environment by harmful emissions and waste. Already today, the area needed to meet Europe's resource demand is estimated to be twice the size of its land area, and the EU is heavily and increasingly reliant on imports to meet this demand.

Much has been said concerning the importance of water for the societal and economic development of Europe. And yet, we still try to solve the problems of the 21st Century using methods of the past, thus condemning our undertaking to certain failure. More than any other domain, the topic of water demonstrates the need to overcome traditional boundaries and schools of thought with regard to such diverse fields as civil engineering, natural sciences, politics, finance and the human sciences.

The domestication of water was the main factor behind the emergence of human civilisation. As a result of current water management practices, cities are more disconnected from their watersheds, and more vulnerable to drought, pollution and flood hazards.

Policies that aim to improve the resilience of our environment, economy and societies, minimise the related threats. In order to design, implement, and monitor the effectiveness of policy measures, they must be based on reliable scientific evidence and, perhaps even more importantly, on social consensus. This evidence-based consensus building, which signifies a new challenge for the world of science, can no longer be carried out in a closed world of anonymous experts. Knowledge is power, and if power is to be the domain of the people then it is our responsibility that this knowledge becomes accessible and understandable to as vast a number of citizens as possible.

The Urban Water Atlas for Europe is an important step in this direction.

The Editorial Board

ANCILLARY INFORMATION

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Water energy
(Energia wody)
Natalia Głowacka, 2016
Częstochowa, Poland

100 x 80
Mixed techniques on canvas.

Artwork photographed by
Kevin Douglas

GLOSSARY

Throughout this publication the following abbreviations, symbols and units have been used

Symbol or Abbreviation	Explanation
°C	Degree Celsius
3D	Three-dimensional
AWWA	American Water Works Association
BAUM	Bundesdeutscher Arbeitskreis für Umweltbewusstes Management
BCI	Blue City Index
BLUESCITIES	Project acronym Blueprints for Smart Cities: Developing the methodology for a coordinated approach to the integration of the Water and Waste sectors within the EIP Smart Cities and Communities
bn	billions
Ca.	circa
cap	Capita (latin: head)
CEFIC	European Chemical Industry Council
CEO	Chief executive officer
cm	centimetre
CO2	Carbon dioxide
CP	Critical point
CTM	Fundació CTM Centre Tecnològic
d	day
DALY	Disability-adjusted-life-year
CDI	Combined drought indicator
DEMOWARE	Project acronym Innovation Demonstration for a Competitive and Innovative European Water Reuse Sector
DG	Directorate-General
DG TAXUD	Directorate-General for Taxation and Customs Union
DMA	District metering area
DMU	De Montfort University
€	EURO – Common European Currency
EC	European Commission
EDO	European Drought Observatory
EEA	European Environment Agency
EIP	European Innovation Partnership
EMF	Ellen-MacArthur-Foundation
EPSRC	Engineering and Physical Sciences Research Council (UK)
et al.	et alii - Latin for "and others"
EUREAU	European Federation of National Associations of Water Services
EWA	European Water Association
fAPAR	Fraction of absorbed photosynthetically active radiation
GBD	Global burden of disease
GPS	Global Positioning System
GWh	Gigawatt hours
GWP1	Gross World Product
GWP2	Global Water Partnership
h	hour
HORIZON 2020	EU Framework Programme for Research and Innovation
ICT	Information and Communication Technology
iDRIP	Project acronym What goes down the drainpipe? Illicit drugs, pollutants & other chemicals in recycled and wastewater
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
iOS	Mobile operating system created and developed by Apple Inc.
IWRM	Integrated water resources management
JRC	Joint Research Centre

Symbol or Abbreviation	Explanation
km	kilometres
kW	kilowatt
kWh	Kilowatt hours
KWR	KWR Watercycle Research Institute
£	British pound
l	litre
LISFLOOD	Distributed Water Balance and Flood Simulation Model
m3	Cubic metre
M/Mio	million
MW	Megawatt(s)
NETWERCH2O	Network for Water in European Cities and Regions
ng/L	Nanogrammes per litre
NUT2	Nomenclature of Units for Territorial Statistics – Level 2, which comprises 276 regions
OECD	Organisation for Economic Co-operation and Development
PE	person equivalent
pers	person
pF	Soil moisture
POC	Pollutants of concern
PRV	Pressure-relief valve (in a water distribution network)
redox	Reduction / oxidation, relating to chemical reactions
$	USA American Dollar
SAT	Soil-aquifer treatment system
SCADA	Supervisory Control and Data Acquisition, a computer-based monitoring and management system commonly used for water supply networks
SDG	Sustainable development goal
SME	Small and medium-sized enterprises
SPI	Standardized precipitation index
SWITCH	Project acronym Sustainable Water Management in the City of the Future
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
USA	United States of America
VTT	VTT Technical Research Centre of Finland Ltd
WDS	Water distribution system
WEI	Water exploitation index
WHO	World Health Organization
WRP	Water recycling plant
WWT	Wastewater treatment
WWTP	Wastewater treatment plant

BIBLIOGRAPHY

This ATLAS is based on a considerable amount of data, data collections and scientific work. The following section aims at given credits to this knowledge used. Being a publication in laymen terms, it would be detrimental to the text to insert quotations at each statement. However, the following bibliography aims to duly respect the acknowledge the underlying scientific work.

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How do we manage water in cities? Where does our drinking water come from? Where does our waste water go? How much water do we consume? Is our life-style affecting our water?

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WATER ART

The cover of the ATLAS features the winners of a school painting competition organised within the context of the new SciArt Water Diplomacy concept. Initiated by the HORIZON 2020 Project BlueSCities and supported by the Network for Water in European Cities and Regions, school pupils in Spain, Turkey, Jordan, Israel, Romania and the United Kingdom illustrated how they perceive water. They were inspired by the artwork of a young emerging artist and scientist from Poland and a series of leading experts in water sciences. The competition involved primary school children from a vast range of social backgrounds; from those suffering the conditions of a refugee camp in Jordan to others who live in wealthy suburban areas of London. Besides the amazing creativity and awareness of these young minds, the competition highlighted the unifying power of water. It showed that we all live and see water in the same way, regardless of our nationality, culture or social status. This understanding sets the foundations for a new form of diplomacy, developed at the municipal level, between the cities, towns and villages in which we all live.

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