KWR 2014.044 | Mei 2014

Urban Water Management Tools

Eindrapport TKI-Watertechnologie project

Watercycle Research Institute

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Projectnummer
400520

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Dit project is mede gefinancierd uit de Toeslag voor Topconsortia voor Kennis en Innovatie (TKI's) van het ministerie van Economische Zaken.

Jaar van publicatie 2014

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Voorwoord

In de komende 20 jaar zullen zich in steden een aantal grote megatrends voordoen. Om de duurzaamheid van de stedelijke waterketen te expliciteren, is de afgelopen jaren veel werk gestopt in het ontwikkelen en toepassen van een indicatorensysteem als baseline assessment voor de kwaliteit van de stedelijke waterketen. Deze tool wordt de City Blueprint genoemd, bestaande uit 24 kwaliteitsindicatoren en is ondertussen toegepast voor 25 steden in binnen- en buitenland. Door Witteveen en Bos is een kostenbatentool- de MKBA-Stad-Tool - ontwikkeld waarmee bepaald kan worden wat de kosten en de baten zijn van het verbeteren van de kwaliteitskenmerken van de stedelijke waterketen. Het project urban water management tools behelst de verdere ontwikkeling van de batentool toegespitst op de stedelijke waterketen om een koppeling te bereiken tussen de City Blueprint en de batentool als vervolgstap in het verduurzamingproces van de stedelijke waterketen.

In dit project zijn een tweetal aspecten verder uitgewerkt:

1) De beoordeling van een aantal Europese steden met de City Blueprint in navolging van het werk dat Siemens in het verleden heeft gedaan aan de European Green City Index, maar dan toegespitst op de duurzaamheid van de stedelijke waterketen.
2) De toepassing van de batentool voor stedelijk water aan de hand van het denkschema van Maatregel naar Kwaliteit naar Baat. Uitgewerkt voor de steden Amsterdam en Eindhoven.

De resultaten van het project zijn weergegeven in 3 notities die in dit rapport gebundeld zijn:

H1: Naar een City Blueprint^{+} op basis van baten

H2: City Blueprints van Eindhoven en Amsterdam

H3: EIP Water. City Blueprints of 25 cities and regions.

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onderwerp	naar een City Blue Print+ op basis van baten
project	TKI Urban Watermanagement Tools
opdrachtgever	KWR
projectcode	NGN142-1
referentie	NGN142-114-000.068
opgemaakt door	mw. dr.ir. E.C.M. Ruijgrok
goedgekeurd door	dr.ir. R.L.J. Nieuwkamer **paraaf**
status	definitief
datum opmaak	3 januari 2014
bijlagen	I. De hoofdindicatoren van de City Blue Print
	II. Vragenlijst voor de City Blue Print+ variant op basis van kosten en baten
	III. Excelspreadsheets voor Amsterdam en Eindhoven

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Inleiding

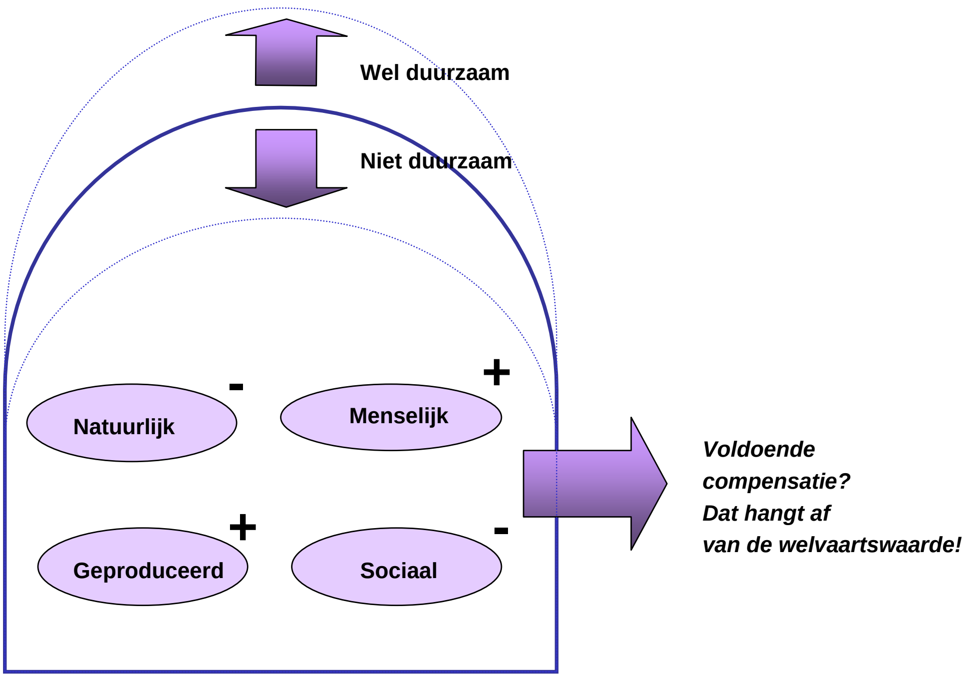
De huidige City Blue Print is een set van 24 indicatoren en nog meer subindicatoren waarmee de mate van duurzaamheid van het stedelijk waterbeheer bepaald kan worden op een gekozen moment. Aan de hand van hun City Blue Print kunnen steden met elkaar wedijveren wie het meest duurzaam is. Ook kunnen zij zien op welke punten zij zich zelf zouden kunnen verbeteren om duurzamer te worden. In deze notitie wordt nagegaan hoe we City Blue Print meer 'kosten- en batengericht' kunnen maken. Het gaat dus om een verdiepingslag waarbij een City Blue Print$^+$ variant ontwikkeld wordt. Dat is belangrijk, interessant en vergroot naar verwachting het onderscheidend vermogen tussen Nederlandse en andere westerse steden. Zo'n City Blue Print plusvariant is belangrijk omdat het nemen van maatregelen op met de City Blue Print gesignaleerde verbeterpunten geld kost, maar de kosten worden in de City Blue Print niet meegenomen. De vraag rijst dan al snel wat dat maatschappelijk gezien oplevert. De verdiepingsslag is interessant omdat het toevoegen van het aspect kosten en baten een stevig welvaartseconomisch fundament biedt voor de City Blue Print, waarmee goed uit te leggen valt waarom een indicator nu juist wel of juist niet iets zegt over duurzaamheid. Tot slot is het voor gebruik binnen één land nuttig om het onderscheidend vermogen van de basisvariant van de City Blue Print te vergroten. De basisvariant werkt goed voor internationale stedenvergelijkingen, maar toont beperkte verschillen in duurzaamheid tussen bijvoorbeeld Nederlandse steden. Het is de bedoeling dat de plus-variant, door toevoeging van indicatoren voor kosten en baten, deze verschillen wel boven water krijgt.

De City Blue Print$^+$ variant hebben wij toegepast op de steden Eindhoven en Amsterdam.

Wat is duurzaamheid?

De oorspronkelijke definitie van de term duurzaamheid, die in 1987 geïntroduceerd werd door mevrouw Brundtland, luidt: *'an economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs'*. Vrij vertaald: er is sprake van duurzaamheid indien toekomstige generaties evenveel welvaart kunnen hebben als de huidige generatie. Hiertoe moet het welvaartsgenerend vermogen van onze omgevingsvoorraden, de motor van onze welvaart, op peil gehouden worden. De vraag is dan ook: hoe kunnen we bepalen of ons natuurlijk (bossen, wateren, olievoorraden etc.), sociaal (regelgeving, organisatiestructuren etc.), geproduceerd (machines, gebouwen etc.), en menselijk (arbeid en kennis) omgevingskapitaal niet krimpt (afbeelding 1)? Of scherper geformuleerd: dat het welvaarts/welzijnsgenererend vermogen van deze voorraden niet krimpt door de keuzes die wij maken?

Afbeelding 1. Maakt een project dat de som van het natuurlijk, sociaal, geproduceerd en menselijk kapitaal groeit of krimpt?



Duurzaamheid meten op basis van voorraden of baten

We kunnen op 2 manieren de krimp/groei van onze kapitaalvoorraden meten:

- door op verschillende momenten te bepalen wat de omvang van elke voorraad in fysieke zin is: dus, hoeveel hectare bos, hoeveel schoon water hebben we nog ten opzichte van een aantal jaar geleden in onze regio? Wanneer de voorraden in fysieke zin krimpen of groeien is dit een voorbode voor wat er met de toekomstige welvaart gaat gebeuren. Immers als voorraden krimpen kunnen zij minder welvaart leveren;
- door een stapje verder te gaan en te bepalen wat er met de welvaarts/welzijnsvoort-brenging gebeurt door de fysieke veranderingen in voorraden. Alleen wanneer we de welvaartswaarden van de voorraden kennen, kan worden vastgesteld of *netto* het welvaartspotentieel is gekrompen/gegroeid. Zonder kennis van de welvaartswaarde van bijvoorbeeld natuur en arbeid, kan niet worden bepaald of netto de welvaart toeneemt/afneemt doordat bijvoorbeeld het natuurlijk kapitaal kromp (minder bos), terwijl tegelijkertijd het menselijk kapitaal groeide (meer hoog opgeleiden).

Met de maatschappelijke kosten-batenanalyse (MKBA) kan dit 'stapje verder' gezet worden. MKBA is immers een analyse van welvaartstoenamen en -afnamen, nu en in de toekomst, waarmee het netto effect op de welvaart wordt bepaald. Met andere woorden: de MKBA is een duurzaamheidstoets, want het kosten-batensaldo geeft aan of de welvaart c.q. het welzijn netto toe- of afneemt. Uiteraard is het dan wel van belang dat echt alle effecten op alle voorraden worden meegenomen in het saldo. En dat is nog niet altijd geval. Met name natuurlijke en sociaal omgevingsvoorraden worden niet altijd goed meegenomen. De uitdaging is dan ook om dat wel te doen.

Voorstel voor indicatoren op basis van baten

Wanneer we er voor kiezen om van de City Blue Print een toets van de welvaart c.q. het welzijn zelf te maken, dient zij geen fysieke voorraadindicatoren maar wel welvaarts- en welzijnsindicatoren te bevatten. De vraag is dan ook wat geschikte indicatoren zijn voor de welvaarts- en welzijnsveranderingen die het waterbeheer teweeg brengt. In essentie is het waterbeheer duurzaam wanneer zij meer maatschappelijke baten oplevert dan dat zij kost. De 2 hoofdindicatoren zijn dan ook: hoge maatschappelijke baten en lage maatschappelijke kosten. Maar wanneer is daar dan sprake van?

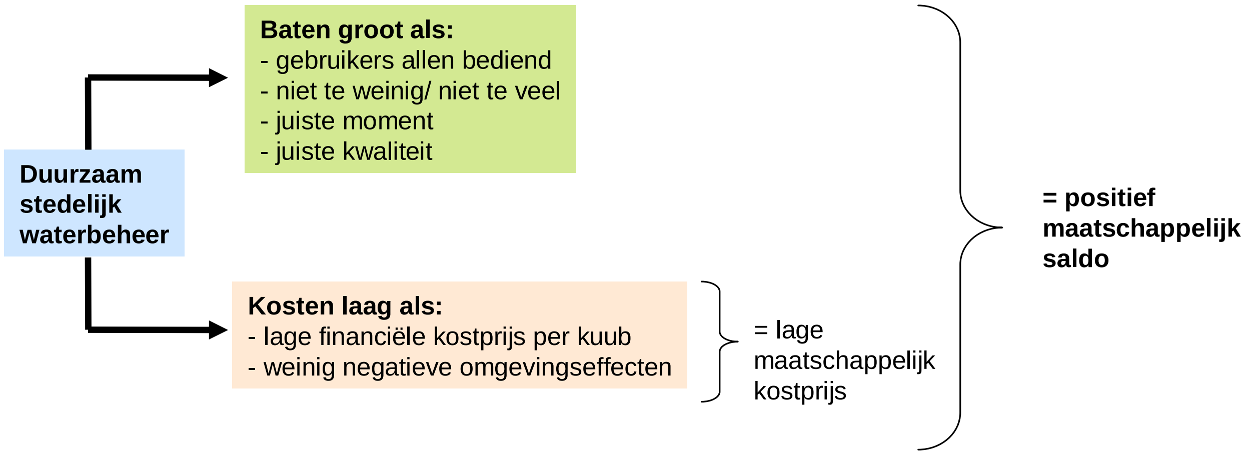
Afbeelding 2 toont dat baten in principe groot zijn wanneer:

- zo veel mogelijk watervragers/gebruikers bediend worden;
- zij niet te weinig water krijgen;
- zij niet te veel water krijgen;
- zij op het juiste moment water krijgen;
- zij de voor hun gebruik geschikte waterkwaliteit krijgen.

Afbeelding 2 toont ook dat kosten in principe laag zijn wanneer:

- het water goedkoop beschikbaar komt (lage financiële kostprijs per kuub);
- de watervoorzienig weinig negatieve (of juist veel positieve) omgevingseffecten voortbrengt.

Afbeelding 2. Wanneer zijn de baten van het stedelijk waterbeheer groot en de kosten klein?



Op grond van afbeelding 2 kan nu voor de gehele waterketen, te weten de watervoorziening, het watergebruik en het afvalwater, alsmede voor het watersysteem, bestaande uit de gebruiksfuncties van oppervlaktewater- en grondwaterlichamen, worden nagegaan wat de handigste indicatoren zijn voor grote baten en lage kosten. Tabel 1 doet hiertoe een aanzet op hoofdlijnen en tabellen 2 en 3 zetten deze om naar concrete meetbare indicatoren. Door zowel aan de hand van de waterketen (tabel 2) als aan de hand van het watersysteem (tabel 3) kosten-batenindicatoren op te sporen, kunnen doublures ontstaan. Deze worden in de eindtabel (tabel 4) weer verwijderd. Aldus ontstaat een set duurzaamheidsindictoren op basis van kosten en baten en dus op basis van welvaart en welzijn. In de eindtabel wordt per indicator een richting aangeven met het oog op het maken van een spinnenwebdiagram.

Tabel 1. Hoofdlijnen duurzaamheidsindicatoren waterbeheer op basis van kosten en baten

	wanneer baten hoog?	**wanneer financiële kosten laag?**	**wanneer zijn negatieve omgevingseffecten klein?**
watervoorziening (wanneer is de voorzieningen duurzaam?)			
inname	als er genoeg onttrokken wordt voor **alle** gebruikers	- weinig investeringen in waterinlaatwerken - weinig pompkosten e.d.	- als er niet meer onttrokken wordt dan wordt aangevuld (door regen, rivieraanvoer, infiltratie, e.d.) - weinig energieverbruik waardoor weinig CO2 uitstoot*
zuivering	als het schoon genoeg wordt voor de gebruikers	goede ruwwaterkwaliteit	- weinig energieverbruik waardoor weinig CO2 uitstoot* - als weinig chemicaliën gebruikt worden en als er weinig restproducten (slib, brijn, e.d.) worden geproduceerd** - als restproducten

			worden hergebruikt ***
transport	als iedereen bereikt wordt	- waterwinning dichtbij gebruikers - weinig verliezen - weinig pompkosten	als weinig energieverbruik waardoor weinig CO2 uitstoot*
watergebruik (wanneer is het gebruik duurzaam/zijn gebruikers duurzaam bezig?)			
huishoudens	n.v.t.	als zij niet meer gebruiken dan nodig is (geen verspilling)	n.v.t.
industrie	n.v.t.	idem d.m.v. - efficiënt productieproces - hergebruik van water (gesloten watersysteem)	n.v.t.
landbouw	n.v.t.	als zij niet meer gebruiken dan nodig is (geen verspilling) en klimaatbestendig zijn d.m.v. : - weinig watervragende gewassen - geen droogtegevoelige gewassen - gerichte bevloeiing	n.v.t.
afvalwater (wanneer wordt het afvalwater duurzaam verwerkt?)			
collectie/riool	voldoende rioolcapaciteit	lage kosten per aansluiting	als het riool niet lekt
behandeling	als het effluent van goede kwaliteit is	- lage behandelingskosten - opbrengsten van gebruik reststoffen	- als weinig energieverbruik waardoor weinig CO_2 uitstoot* - als weinig chemicaliën worden gebruik en als er weinig restproducten (slib, brijn, e.d.) worden geproduceerd**
lozing	- als effluent het ontvangend oppervlaktewater minimaal belast - als effluent wordt hergebruikt	- lage lozingskosten (vrij verval) - opbrengsten van hergebruik effluent	als het effluent van goede kwaliteit is
oppervlaktewatersysteem (welke functies vervult het oppervlaktewatersysteem voor de mens in de stad?)			
veiligheid tegen overstromingen	als risico op overstromingsschade laag (risico = kans x	als weinig investeringen in kunstwerken (dijken, dammen, gemalen)	geen barrièrewerking: - als kunstwerken watersysteem niet

	gevolgschade)	nodig zijn	versnipperen (vismigratie) - als kunstwerken niet hoog zijn (uitzicht)
scheepvaart	als de waterdiepte groot genoeg is (diepte = waterstand - bodemhoogte)	- als er weinig gebaggerd hoeft te worden - als er weinig stuwen en sluizen nodig zijn	- als er weinig gebaggerd hoeft te worden (troebelheid) - geen barrièrewerking - geen lozingen vanaf de schepen
recreatie en natuur	- als oeverinrichting mooi is - als waterkwaliteit goed	- als weinig oeveronderhoud - als lage zuiveringskosten	- als de recreatiedruk de draagkracht van de natuur niet overstijgt
koelwaterwinning voor elektriciteit en industrie	als voldoende koelwater beschikbaar	- als lage pompkosten	- als geen hete lozingen - als laag energieverbruik door de pompen
visserij	als er veel oogstbare vis is, dus goede waterkwaliteit en goede ecologische inrichting	- als lage zuiveringskosten - als lage herinrichtingskosten	als visserij geen negatief effect heeft op het ecosysteem: - geen overbevissing; - geen slechte (bijv. bodemroerende) vistechnieken
delfstoffenwinning (zand, grind, klei)	als er veel delfstoffen gewonnen kunnen worden	- als dichtbij bouwprojecten (kleine transportafstanden)	- als goede waterkwaliteit (geen invloed op troebelheid) - als goede herinrichting
landbouw	als voldoende water en dus grote oogsten	als lage pompkosten	als goede waterkwaliteit (geen pesticiden en nutriënten in het water)
grondwatersysteem (welke functies vervult het grondwatersysteem voor de mens in de stad?)			
bebouwing en infrastructuur	juist grondwaterpeil (niet te hoog, niet te laag)	weinig waterbeheerskosten: drainage, pompen, infiltratie, etc.	- als functies die hetzelfde peil verlangen gebundeld zijn in 1 gebied - als er geen bodemdaling ontstaat
landbouw en natuur (planten)	idem	idem	idem
winning t.b.v. drinkwater en proceswater	idem	idem	idem

* Het energieverbruik zelf zit in de financiële kosten per kuub, de waarde van de uitstoot niet. De uitstoot loopt echter parallel met de omvang van het energiegebruik, tenzij men groene energie (wind, zon) gebruikt.

** Het chemicaliëngebruik zelf zit in de financiële kosten per kuub. De vraag is of dit gebruik nog negatieve effecten heeft anders dan het opraken van voorraden. In dat geval is het welvaartseffect doorgaans dat een duurdere grondstof in nodig is in de toekomst.

*** Kan achterwege blijven als de opbrengsten hiervan verwerkt zijn in de kuubprijzen van het water.

Tabel 2. Duurzaamheidindicatoren watervoorziening

	indicator	**meeteenheid**	**richting**
overkoepelende indicatoren watervoorziening	kosten van watervoorziening	euro/kuub drinkwater euro/kuub industriewater euro/kuub landbouwwater	hoe lager, hoe beter
	klimaatbijdrage	CO_2-uitstoot van het voorzieningssysteem per kuub water	hoe lager, hoe beter[1]
inname	toekomstvastheid	is een toekomstbestendige bron aanwezig? ja/nee	ja=goed, nee=slecht
transport	toegankelijkheid tot water van gewenste kwaliteit	% van bevolking met toegang tot betrouwbaar drinkwater % van industrie met toegang tot bruikbaar proceswater van gewenste kwaliteit % van landbouwbedrijven met toegang tot bruikbaar water voor vee en gewas	hoe hoger, hoe beter
transport	leveringszekerheid	aantal uitvalincidenten per jaar	hoe lager, hoe beter
overkoepelende indicatoren watergebruik	n.v.t.	n.v.t.	n.v.t.
huishoudens	geen verspilling*	kuub/persoon/jaar	hoe lager, hoe beter
industrie	geen verspilling	kuub/euro omzet/jaar	hoe lager, hoe beter
landbouw	geen verspilling	kuub water/hectare/jaar ja/nee voor waterzuinige irrigatietechnieken of	hoe lager, hoe beter ja=goed, nee=slecht

1 Brabant Water is in 2013 klimaatneutraal (CO2-uitstoot is gelijk aan nul), dus de Eindhovense drinkwatervoorziening is dat ook. Beter nog dan klimaatneutraal is als er koolstof uit de atmosfeer wordt vastgelegd.

		gewassen	
overkoepelende indicator afvalwater	kosten afvalwaterverwerking	EUR/aansluiting/jaar	hoe lager, hoe beter
	klimaatbijdrage	CO_2-uitstoot van het afvalwatersysteem per kuub water	hoe lager, hoe beter
collectie/riool	toegankelijkheid riolering rioolcapaciteit	% huishoudens/bedrijven aangesloten op riool of iets vergelijkbaars** aantal overstortincidenten per jaar***	hoe hoger, hoe beter hoe lager, hoe beter
behandeling	effluentkwaliteit	kwaliteit effluent niet slechter dan gewenste kwaliteit oppervlakte water waarop geloosd wordt: ja/nee	ja=goed, nee=slecht
lozing	hergebruik effluent	% hergebruikt effluent	hoe hoger, hoe beter

* In Nederland zou ook de indicator 'aantal huishoudens met kapotte waterapparaten' als indicator gebruikt kunnen worden in verband met de hardheid van het water. Dit is onderscheidend tussen gebieden.

** Alleen riool is niet zuiver, want er bestaan ook septic tanks, zuiveringsmoerassen en andere lokale kleinschalige zuiveringssystemen e.d.

*** Geldt alleen voor gemengde rioolstelsels.

Tabel 3. Duurzaamheidindicatoren watersysteem

	indicator	**meeteenheid**	**richting**
oppervlaktewatersysteem (welke functies vervult het oppervlaktewatersysteem voor de mens in de stad?)			
overkoepelende indicatoren oppervlaktewaterbeheer	kosten van oppervlaktewaterbeheer (peil en waterkwaliteit, baggeren, herinrichten)	euro/persoon//jaar	hoe lager, hoe beter
veiligheid tegen overstromingen	overstromingsrisico	verwachte schade (euro/jaar)	hoe kleiner hoe beter
scheepvaart	waterdiepte voldoende voor scheepvaart?	ja/nee	ja=goed, nee=slecht

recreatie en natuur	- % natuurlijk ingerichte oevers - is water veilig en schoon voor mensen om te zwemmen? - recreatie in balans met natuurlijke draagkracht?	- km natuurvriendelijk/ km totale oeverlengte - voldoet water aan zwemwaternormen (ja/nee) - in balans: ja/nee	hoe meer, hoe beter ja=goed, nee=slecht
koelwaterwinning voor elektriciteit en industrie	- frequentie van inname-stops vanwege te weinig rivierwater - frequentie van te hoge temperatuur van het water	- aantal stops/jaar - aantal normoverschrijdingen watertemperatuur in de rivier/jaar*	hoe minder, hoe beter
visserij	- % natuurlijk ingerichte oevers - is waterkwaliteit voldoende voor vis? - toekomstbestendigheid	- km natuurvriendelijk/km totale oeverlengte - voldoet water aan viswaternormen (ja/nee) - is er geen sprake van overbevissing of 'slechte' vistechnieken?(ja/nee)	hoe meer, hoe beter ja=goed, nee=slecht ja=goed, nee=slecht
delfstoffenwinning (zand, grind, klei)	kosten van gewonnen zand, klei, grind**	euro/ton	hoe lager, hoe beter
landbouw	goede waterkwaliteit: is waterkwaliteit voldoende voor zwemmers en vis (nutriënten en pesticiden?	voldoet water aan zwemwater- en viswaternormen (ja/nee)	ja=goed, nee=slecht
winning t.b.v. drinkwater en proceswater	zuiveringskosten door slechte oppervlaktewaterkwaliteit[1]	euro/kuub	hoe lager, hoe beter
grondwatersysteem (welke functies vervult het grondwatersysteem voor de mens in de stad?)			
overkoepelende indicatoren grondwaterbeheer	kosten van grondwaterbeheer (peil en waterkwaliteit)	euro/persoon/jaar	hoe lager, hoe beter

[1] Deze indicator overlapt (dubbeltelling) met de eerste indicator van tabel 2: kosten van watervoorziening.

bebouwing en infrastructuur	grondwaterpeil te hoog/te laag	% van gebied met grondwateroverlast (te veel of te weinig) of schade in euro/jaar	hoe minder, hoe beter
landbouw en natuur (planten)	schade door grondwateroverlast (te hoog/te laag) of slechte grondwaterkwaliteit	% van gebied met grondwateroverlast (te veel, te weinig, te zilt) of schade in euro/jaar	hoe minder, hoe beter
winning t.b.v. drinkwater en proceswater	zuiveringskosten door slechte grondwaterkwaliteit[1]	euro/kuub	hoe lager, hoe beter

* Indien er geen norm is voor de temperatuur, dan kan het aantal gevallen met vissterfte worden geteld.

** Als de kosten laag zijn, dan is de winning blijkbaar makkelijk, zijn de transportafstanden klein en is de herinrichting goed te doen.

Wanneer we tabellen 2 en 3 samenvoegen en alle dubbeltellingen eruit halen, blijft een set van 24 kosten-batenindicatoren over die gezamenlijk laten zien hoe duurzaam het waterbeheer van een stad is en waar dat aan ligt. Tabel 4 toont deze set, die meteen vertaald is in het Engels met het oog op internationaal gebruik.

Tabel 4. Water management sustainability indicators based on costs and benefits

	indicator	**unit**	**direction of preference**
	Water supply (intake, treatment, transport, use, waste water: sewage, treatment and discharge)		
1	water supply costs	euro/m^3 drinking water euro/m^3 industrial process water euro/m^3 water for agriculture	the lower, the better
2	contribution to climate change	CO_2-emission/m^3 water supply CO_2-emission/m^3 waste water	the lower, the better
3	future proof water intake	is a future proof water source available? yes/no	yes=good, no=bad

[1] Deze indicator overlapt (dubbeltelling) met de eerste indicator van tabel 2: kosten van watervoorziening.

4	accessibility to water of suitable quality	% of population with reliable drinking water % of industries with suitable process water % of farms with suitable water for live stock and crops	the higher, the better
5	water supply security	number of water supply stops per year	the lower, the better
6	water wasting/over use	m^3 water use/person/year m^3 water use/euro turn over/year in industry m^3 water use/hectare agricultural land/year *(or: yes/no water saving irrigation and crop choice)*	the lower, the better *yes=good, no=bad*
7	waste water costs	EUR/sewage connection/year	the lower, the better
8	access to safe sanitation	% households and industries connected to sewage or comparable sanitation systems	the higher, the better
9	sewage capacity	number of untreated discharge to surface water incidents per year	the lower, the better
10	effluent quality	effluent quality is equal or better than desired surface water quality of receiving surface water: yes/no	yes=good, no=bad
11	reuse of effluent	% of effluent reused	the higher, the better
surface- and groundwater system			
12	surface water management costs	euro/person//year	the lower, the better
13	flood risk	expected flood damage (euro/year)	the lower, the better
14	water depth for ships	sufficient depth: yes/no	yes=good, no=bad
15	balance recreational use and natural carrying capacity	balance: yes/no	yes=good, no=bad
16	natural river banks	km nature friendly river banks/total km of river banks	the more, the better
17	frequency of cool water intake stops due to water shortage	number of stops/year	the fewer, the better

18	frequency of thermal pollution (i.e. high water temperature)	number of high temperature incidents/year (or: number of fish dying incidents/year)	the fewer, the better
19	future proof fisheries	no over use nor bad fishing techniques: yes/no	yes=good, no=bad
20	mining costs**	euro/ton sand, gravel etc.	the lower, the better
21	water quality sufficient for fish and swimming?	sufficient: yes/no	yes=good, no=bad
22	ground water management costs (quantity & quality)	euro/person/year	the lower, the better
23	ground water nuisance (or damage)	% of the city with ground water nuisance (or damage in euro/year)	the lower, the better
24	groundwater quality damage	% of the city with salty water nuisance (or crop damage/year)	the lower, the better

* In the Netherlands one could also use the indicator 'number of households with broken appliances' in relation to the calcium level of drinking water. This will show differences between cities.

** If mining costs are low, then mining is apparently easy, the transport distances are small.

Vergelijking van tabel 4 met de oorspronkelijke City Blue Print

Het is interessant de indicatoren van tabel 4 te leggen naast die van de oorspronkelijke City Blue Print (zie bijlage I). We zien dat de oorspronkelijke City Blue Print vrijwel geen kostenindicatoren bevat en tabel 4 juist wel. Ook indicatoren voor gebruiksfuncties van het watersysteem, zoals scheepvaart en visserij komen niet voor in de bestaande City Blue Print, maar wel in tabel 4.

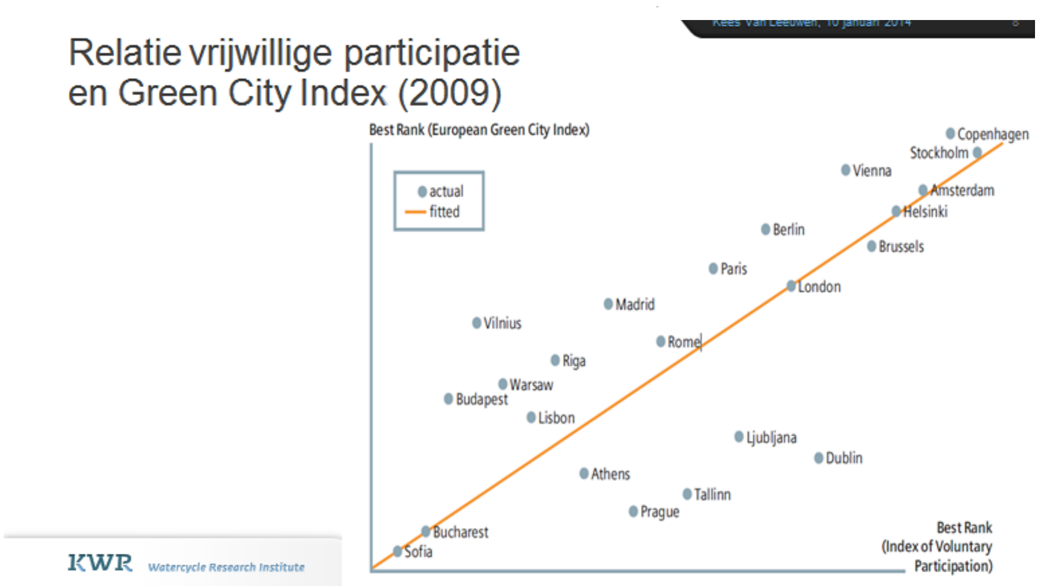
Enkele indicatoren uit de oorspronkelijke City Blue Print komen niet voor in tabel 4. Dit geldt bijvoorbeeld voor:

- grondwaterkwaliteit in relatie tot drinkwater: dit is een voorwaarde c.q. oorzaak van lage kosten per kuub drinkwater en zou dus dubbel tellen met de financiële kostprijs;
- staat van onderhoud van de leidinginfrastructuur voor drinkwater en rioolwater: als leidingen in goede staat verkeren hoeft dat op zich niet te betekenen dat het een duurzaam leidingstelsel betreft. Een goede staat kan betekenen dat de leidingen net zijn vervangen en we weten niet of de baten van de vervanging de kosten overtreffen. Wel is het zo dat een slechte staat leidt tot verhoogde risico's ten aanzien van levering en vervuiling van grondwater en hogere infectierisico's (volksgezondheidsproblemen), bijvoorbeeld door breuk van rioolpijpen. Voor een drinkwaterbedrijf zijn dit cruciale aspecten in relatie tot imago bij klanten. Daarom heeft de staat van onderhoud hoge prioriteit bij drinkwaterbedrijven. In deze City Blue Print+ is dit aspect ondervangen door middel van de indicators 'accessibility to water of suitable quality' en 'water supply security';
- scheiding van afval- en regenwater: we weten op voorhand niet of deze maatregel duurzaam is of niet, omdat een verbeterd gescheiden stelsel zowel voor- als nadelen heeft ten opzichte van een

gemengd rioolstelsel. Een groot voordeel van een verbeterd gescheiden stelsel is dat er geen ongezuiverd rioolwater meer overstort op de stadswateren, met zuurstofloosheid, vissterfte, stank en vervuiling als gevolg. Deze problematiek heeft zeker effect op de kwaliteit van de openbare ruimte in de bebouwde omgeving. Een nadeel van verbeterd gescheiden stelsels is de kans op verkeerde aansluitingen, waardoor er onbedoeld continue vervuiling van het oppervlaktewater plaats vindt. Ook blijken de regenwaterriolen zelf een bron van vervuiling met ingevangen organisch materiaal te zijn en ze zijn vaak duurder. Kortom, de keuze voor een verbeterd gescheiden stelsel of een gemengd stelsel vraagt per geval een goede kosten-batenanalyse. Op voorhand zeggen dat een verbeterd gescheiden duurzamer is dan een gemengd stelsel is te kort door de bocht;

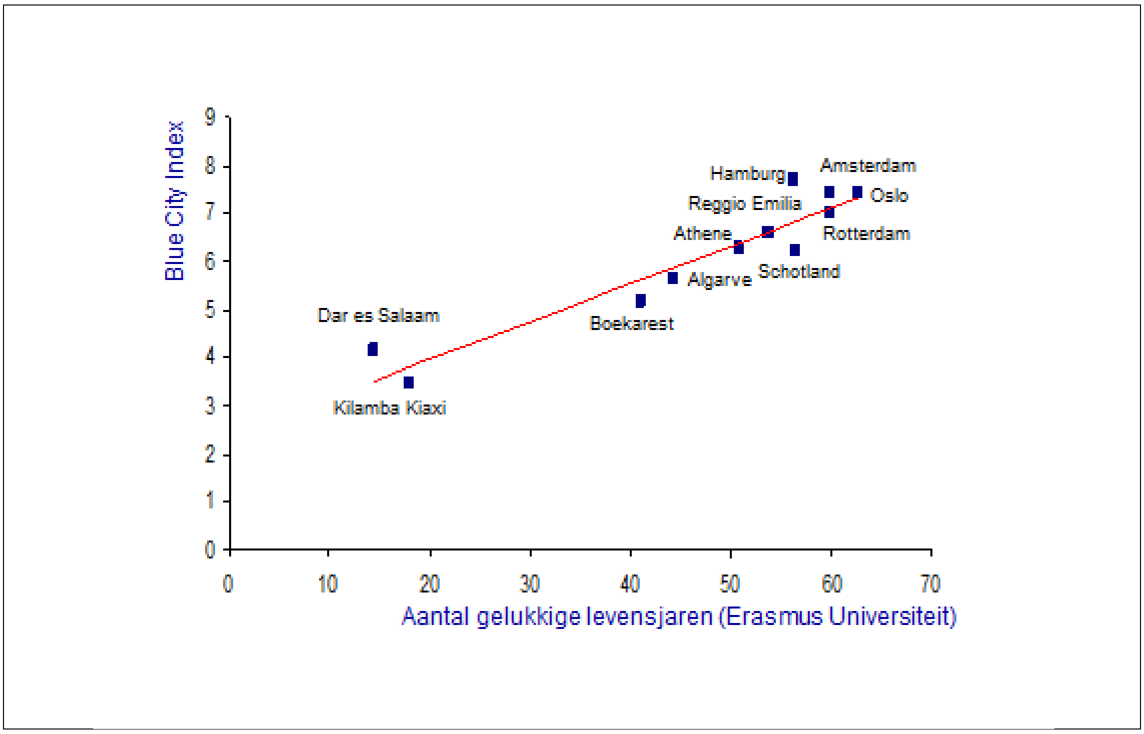
- local authorities commitment: dit telt in principe dubbel met andere indicatoren, want commitment leidt tot het nemen van maatregelen (en als dat niet zo is, heb je er niets aan en draagt het zeker niet bij aan duurzaamheid);
- publieke participatie: we weten niet of dat duurzaam is: het kan ook vertragend en dus kosten verhogend werken. Het kan ook leiden tot oneerlijke verdeling van water door machtsverschillen tussen partijen. Toch blijkt er volgens Siemens er een positieve relatie te bestaan tussen de Green City Index en de vrijwillige participatie (afbeelding 3).

Afbeelding 3. Relatie tussen Green City Index en vrijwillige participatie



- biodiversiteit: dat is een voorbode voor eventuele menselijke welvaart. Zou als alternatief kunnen dienen voor de baten van oppervlaktewaterkwaliteit, want als alle diersoorten er zijn is het waarschijnlijk ook relatief goed voor de volksgezondheid. Biodiversiteit oppervlaktewater is inderdaad goede maat voor omgevingskwaliteit, volksgezondheid en recreatie. Mensen zijn blij en leven langer in blauwe steden, zoals blijkt uit de relatie in afbeelding 4.

Afbeelding 4. Relatie tussen Blue City Index en Aantal gelukkige levensjaren



We zien ook overeenkomsten, dat wil zeggen indicatoren die zowel in tabel 4, als in de bestaande City Blue Print voorkomen. Dit geldt bijvoorbeeld voor:

- the water footprint die enigszins overeenkomt met indicator 6 'verspilling' die ook gaat over hoeveel water er per persoon, per euro omzet in de industrie en per hectare landbouw gebruikt wordt;
- safe sanitation die overeenkomt met indicator 8 'sewage accessibility' en sludge quality het geen matcht met indicator 10 'effluent quality';
- attractiveness, welke correspondeert met indicator 16 'natural river banks' en indicator 21 'sufficient quality for fishing and swimming'.

Een en ander betekent dat men op grond van baten en kosten tot een andere set van duurzaamheidsindicatoren komt, dan die van de bestaande City Blue Print. Maar, toeval of niet, in beide gevallen is de set beperkt tot 24 indicatoren.

Toepassing op Eindhoven en Amsterdam

Tabel 5 bevat de verzamelde gegevens voor beide steden. In de bijlage staan de Excel-sheets met de gedetailleerde berekeningen en de bronverwijzingen.

Tabel 5. Verzamelde gegevens van indicatoren voor Eindhoven en Amsterdam

	indicator	**unit**	**direction of preference**	**Eindhoven**	**Amsterdam**
Water supply (intake, treatment, transport, use, waste water: sewage, treatment and discharge)					
1	water supply costs	euro/m^3 drinking water euro/m^3 industrial process water euro/m^3 water for agriculture	the lower, the better	0,63 - 0,10	1,24 - 0,03
2	contribution to climate change	kg CO_2-emission/m^3 water supply kg CO_2-emission/m^3 waste water	the lower, the better	0 0,17	0,24 -
3	future proof water intake	is a future proof water source available? yes/no	yes=good, no=bad	yes	yes
4	accessibility to water of suitable quality	% of population with reliable drinking water % of industries with suitable process water % of farms with suitable water for live stock and crops	the higher, the better	100 100 100	100 100 100
5	water supply security	number of water supply stop dayss per year - households - industry - agriculture (using surface water)	the lower, the better	0 0 62	0 0 -

		- agriculture (using groundwater)		15	-
6	water wasting/ over use	m^3 water use/person/year m^3 water use/euro turn over/year in industry m^3 water use/hectare agricultural land/year *(or: yes/no water saving irrigation and crop choice)*	the lower, the better *yes= good, no= bad*	45 - 608	57[1] - 395
7	waste water costs	EUR/sewage connection/year - households - companies	the lower, the better	 360 641	 443 722
8	access to safe sanitation	% households and industries connected to sewage or comparable sanitation systems	the higher, the better	100	100
9	sewage capacity	number of untreated discharge to surface water incidents per year	the lower, the better	-	-
10	effluent quality	effluent quality is equal or better than desired surface water quality of receiving surface water: yes/no	yes=good, no=bad	no	no
11	reuse of effluent	% of effluent reused	the higher, the better	-	-

	indicator	unit	direction of preference	Eindhoven	Amsterdam
		Surface- and groundwater system			
12	surface water management costs	euro/person//year - water quantity management - water quality management	the lower, the better	 34,50 46,44	 93,24 54,00

[1] Inclusief verbruik door bedrijven en industrie, dus slecht vergelijkbaar met Eindhoven.

13	flood risk	expected flood damage (euro/year) expected flood frequency (1/year)	the lower, the better	- 100	- 1.000
14	water depth for ships	sufficient depth: yes/no Note that dredging costs are included in water quantity management costs (indicator 12)	yes=good, no= bad	n.a.	yes
15	balance recreational use and natural carrying capacity	balance: yes/no	yes=good, no=bad	yes	-
16	natural river banks	km nature friendly river banks/total km of river banks	the more, the better	17	1,6 + pm
17	frequency of cool water intake stops due to water shortage	number of stops/year	the fewer, the better	n.a.	0
18	frequency of thermal pollution (i.e. high water temperature)	number of high temperature incidents/year (or: number of fish dying incidents/year)	the fewer, the better	n.a.	<1
19	future proof fisheries	no overuse nor bad fishing techniques: yes/no	yes=good, no= bad	yes	no
20	mining costs**	euro/ton sand, gravel etc.	the lower, the better	n.a.	n.a.
21	water quality sufficient for fish and swimming?	sufficient: yes/no	yes=good, no=bad	yes	yes
22	ground water management costs (quantity & quality)	euro/1.000 m^3	the lower, the better	19	13
23	ground water nuisance (or damage)	% of the city with ground water nuisance (or damage in euro/year)	the lower, the better	15	30

24	groundwater quality damage	% of the city with salty water nuisance (or crop damage/year)	the lower, the better	0	0

Interpretatie van de resultaten

De kosten van drinkwatervoorziening en waterbeheer zijn in Amsterdam fors duurder dan in Eindhoven, zoals blijkt uit indicator 1 (97 % duurder). Dit verschil is waarschijnlijk te verklaren doordat de drinkwatervoorziening voor Amsterdam moeilijker is (rivierwater transporteren naar en infiltreren in de duinen en vervolgens transport van drinkwater van de duinen naar de stad) dan in Eindhoven waar gebruik gemaakt wordt van diep grondwater.

Voor Eindhoven zien we dat het landbouwwater 3 maal zo duur is als in Amsterdam, terwijl de leveringszekerheid ook lager is dan A'dam.

Het energieverbruik van Waternet en Brabant Water is vrijwel gelijk: 0,4 kWh/m^3. Dat is 0,24 kg CO_2/m^3. Gerekend met grijze stroom (0,59 $kgCO_2/kWh$). Indien groene stroom gebruikt wordt gaat dit richting 0. Het energieverbruik is veruit het grootste aandeel in de klimaatvoetafdruk. Op tweede plaats komt het indirecte energieverbruik door chemicaliën. Het chemicaliën verbruik zal voor Amsterdam hoger zijn dan Eindhoven, maar specifieke getallen hiervoor hebben we niet. Eindhoven is in 2013 klimaatneutraal geworden, vandaar dat in de tabel de CO_2-emissie voor drinkwaterproductie in Eindhoven op nul gezet is.

Indicator 3 laat zien dat beide steden de beschikking hebben over een duurzame bron voor de drinkwaterbereiding. Dit is dus niet onderscheidend.

Indicatoren 4 en 5 laten zien dat het drinkwaterstelsel in beide steden goed op orde is.

Het waterverbruik per persoon verschilt waarschijnlijk weinig tussen beide steden.

De kosten voor het zuiveren van afvalwater (indicator 7) verschilt behoorlijk. In Amsterdam is dat 13 % (huishoudens) en 23 % (bedrijven) duurder dan in Eindhoven. Wellicht dat er een efficiencyslag te maken is in Amsterdam.

In beide steden is het afvalwatersysteem goed op orde (indicatoren 8 en 9). Hoewel we geen gegevens voor indicator 9 konden vinden, vermoeden wij dat de rioolcapaciteit voldoende is in beide steden om grote waterkwaliteitsproblemen in het oppervlaktewater te voorkomen. Echter, in beide steden belast het effluent het oppervlaktewater nog steeds (indicator 10). De vraag rijst dus of beide steden iets kunnen doen om hun effluentkwaliteit te verbeteren.

Over de mate waarin effluent wordt hergebruikt (indicator 11) konden wij nog geen gegevens vinden.

Het beheer van het oppervlaktewater blijkt in Amsterdam ook duurder te zijn dan in Eindhoven. Op zich lijkt dat logisch, omdat Amsterdam veel meer oppervlaktewater heeft (grachten, havens) dat onderhouden moet worden dan Eindhoven. Dit heeft alles te maken met de geografische ligging van beide steden: Amsterdam in het lage westen en Eindhoven op de hoge zandgronden.

De veiligheidsnorm voor overstromingen vanuit het regionale watersysteem zijn in Amsterdam veel strenger dan in Eindhoven. Dit is ook verklaarbaar vanuit de geografische ligging van beide steden. Helaas was de verwachte overstromingsschade niet te achterhalen, want daaruit zouden we kunnen zien of het overstromingsrisico (kans maal gevolgschade) gelijk is of niet.

Verder blijkt dat de lengte van natuurvriendelijke oevers moeilijk te achterhalen is, hoewel dit een gemakkelijk te meten indicator is, houden de waterbeheerders dit gegeven niet bij. Amsterdam heeft honderden kilometers aan oevers en we konden maar 1,6 km natuurvriendelijke oever vinden, terwijl Amsterdam behoorlijk actief is met stadsecologie. Dit blijkt echter nog niet uit de gevonden gegevens. Hier ligt nog een grote opgave.

De kosten van het grondwaterbeheer verschillen ook behoorlijk, maar in dit geval is Eindhoven duurder dan Amsterdam. Eindhoven heeft de helft minder gebieden met grondwateroverlast dan Amsterdam (15 % versus 30 %). De oorzaken van dit verschil zijn niet bekend,

Onderscheidend vermogen

Natuurlijk is het mooi om een City Blue Print$^+$ plusvariant te hebben die een doorvertaling maakt naar kosten en baten en die methodisch aansluit bij de Brundlandt-definitie van duurzaamheid. Nog mooier is het wanneer deze plusvariant in staat is om meer onderscheid te maken tussen de mate van duurzaamheid van stedelijke waterbeheer in Europese steden en in het bijzonder in Nederlandse steden. Met de oorspronkelijke City Blue Print is er weinig onderscheid tussen Nederlandse steden. Dit is op zich niet verrassend want het waterbeheer in Nederland is overal ongeveer op dezelfde wijze georganiseerd en goed op orde. Het blijkt uit het voorbeeld van Amsterdam en Eindhoven dat de nieuwe set van indicatoren inderdaad meer onderscheid oplevert met name door de kostprijs per kuub, een sterke indicator waarin ook allerlei milieuaspecten verwerkt zitten, zoals ruwwaterbron, energiekosten en opbrengsten van reststoffengebruik. Ook hebben we andere aspecten van het waterbeheer meegenomen, zoals de waterveiligheid en visserij, waardoor er meer verschillen tussen steden kunnen worden opgespoord.

Conclusie

De bovenstaande tabel 5 geeft een indicatie waar verschillen zitten in het waterbeheer tussen steden. De tabel laat niet zien waardoor de verschillen worden veroorzaakt. Deze tabel kan gebruikt worden om onderdelen in het waterbeheer op te sporen waar het misschien duurzamer kan. Dit is ook waar de index voor bedoeld is. Vervolgens moet in een vervolgstudie een systeemanalyse gedaan worden om achter de oorzaak van de verschillen te komen. Op basis van die analyse kunnen we maatregelen ontwerpen die we op kosten en baten zetten. De kosten-batenanalyse maakt duidelijk of de stad haar waterbeheer duurzamer kan maken of niet. Als je geen kosten-batenanalyse voor de maatregelen opstelt, verbetert immers een baatindicator terwijl tegelijk een kostindicator omhoog gaat zonder dat je weet of dat elkaar voldoende compenseert.

Bijlage 1 De hoofdindicatoren van de City Blue Print

De 24 kwaliteitsindicatoren voor het stedelijk watersysteem (City Blueprint)		
Water security	*Sanitation*	*Climate robustness*
1. Total water footprint	11. Safe sanitation	18. Local authority commitments
2. Water scarcity	12. Sewage sludge quality	19. Safety
3. Water self-sufficiency	13. Energy efficiency	20. Climate-robust buildings
Water quality	14. Energy recovery	*Biodiversity and attractiveness*
4. Surface water quality	15. Nutrient recovery	21. Biodiversity
5. Groundwater quality	*Infrastructure*	22. Attractiveness
Drinking water	16. Maintenance	*Governance*
6. Sufficient to drink	17. Separation of waste & stormwater	23. Management and action plans
7. Water system leakages		24. Public participation
8. Water efficiency		
9. Consumption		
10. Quality		

Bijlage 2 Vragenlijst voor de City Blue Print+ variant op basis van kosten en baten

Hier treft u een vragenlijst aan om de duurzaamheid van het waterbeheer in een stad te bepalen aan de hand van baten- en kostenindicatoren. Hoewel het antwoord op de vragen wellicht verschillend is voor de verschillende waterlichamen of wijken in uw stad, is het niet de bedoeling om de vragen per waterlichaam of per wijk te beantwoorden. Bij bijv. vraag 21 wordt gevraagd of het waterkwaliteit goed genoeg is om in te zwemmen. Het gaat er dan om of dat grosso modo het geval is in de stad of niet.

Voor alle, maar in het bijzonder voor de vragen over kosten, geldt dat het gaat om een globale inschatting van het gemiddelde. Omdat waterbeheerkosten niet in elk land op een zelfde manier doorgerekend worden aan burgers en bedrijven, zijn de kostenvragen algemeen geformuleerd. Voor Nederland gelden echter de volgende aanwijzingen:

- vraag 1: af te leiden uit de rekening van het drinkwaterbedrijf;
- vraag 7: af te leiden uit rioolheffing per aansluiting of vervuilingeenheid die in rekening wordt gebracht door de gemeente;
- vraag 12, onderdeel waterkwantiteit: de kosten van het waterkwantiteitsbeheer zijn gelijk aan de watersysteemheffing per persoon (1 huishouden is 1,2 personen) zoals in rekening gebracht door het waterschap. Voor een inschatting van de totale kosten voor waterkwantiteit dienen hierbij de kosten die het rijk maakt voor de veiligheid te worden opgeteld. Het is even de vraag hier voldoende gegevens voor beschikbaar zijn. Het verzoek is dan ook om aan te geven of de ingevulde bedragen alleen waterschapsbedragen zijn of dat er rijksuitgaven bij op zijn geteld en hoeveel dan;
- vraag 12, onderdeel waterkwaliteit: het gaat hier om de kosten van het waterkwaliteitsbeheer anders dan de rioleringskosten, die reeds bij vraag 7 zijn ingevuld. Het gaat dus om de zuiveringsheffing die het waterschap in rekening brengt per persoon (1 huishouden is 1,2 personen);
- vraag 22 over grondwater: dit is in Nederland een lastige vraag, want in principe is de gemeente verantwoordelijk voor het beheer van het ondiepe grondwater, maar er is geen aparte belasting voor. Ook is niet duidelijk of er kosten voor grondwaterkwantiteit en -kwaliteit in de watersysteemheffing van het waterschap zitten. Het verzoek is dan ook om na te gaan of er wel of geen grondwaterkosten in het antwoord op vraag 12 zijn verwerkt.

Uit het bovenstaande blijkt dat deze vragenlijst nog in ontwikkeling is. Uit testcases zal moeten blijken wat handig is en wat niet. Wij vragen daarvoor uw begrip.

Table II.1 Water management sustainability indicators based on costs and benefits

	indicator	**unit**	**direction of preferente**
	Water supply (intake, treatment, transport, use, waste water: sewage, treatment and discharge)		
1	**What are the average supply (production + transport) costs of drinking water, industrial process water and agricultural water?**		
	water supply costs	… euro/m^3 drinking water … euro/m^3 industrial process water … euro/m^3 water for agriculture	the lower, the better
2	**What is the CO_2-emission of water supply (production + transport) and waste water (collection + treatment + discharge)?**		

	contribution to climate change	… kg CO_2-emission/m³ water supply … kg CO_2-emission/m³ waste water	the lower, the better
3	**Is the annual water intake smaller than the annual feed (rain, river, etc.) of the water stock? In other words, what is the water balance in your city?**		
	future proof water intake	water intake is smaller than available water resource? yes/no If possible specify the volume of the balance in m³ positive or negative: … m³/year	yes= good, no= bad
4	**How many percent of the households, the industries and farms have access to reliable drinking water, suitable process water and suitable water for live stock and crops?**		
	accessibility to water of suitable quality	… % of households with reliable drinking water … % of industries with suitable process water … % of farms with suitable water for live stock and crops	the higher, the better
5	**On average, how many water supply stops occur in your city every year? Please, specify this for households, industries and farms.**		
	water supply security	… water supply stops for households per year … water supply stops for industries per year … water supply stops for farms per year	the lower, the better
6	**On average, what is the water use in your city every year? Please, specify this for households, industries and farms and mind the units that are specified below.**		
	water wasting/over use	… m³ water use/person/year … m³ water use/euro turn over/year in industry … m³ water use/hectare agricultural land/year *(or: yes/no water saving irrigation and crop choice)*	the lower, the better *yes= good, no= bad*
7	**On average, what are the waste water costs (collection + treatment + discharge) per sewage connection? Specify for households and companies.**		
	waste water costs	… EUR/sewage connection/year for households … EUR/sewage connection/year for	the lower, the better

		companies *(or … EUR/pollution unit/year)*	
8	**On average, how many percent of the households and companies are connected to the sewage or a comparable sanitation system, like a septic tank?**		
	Access to safe sanitation	… % households connected to sewage or comparable sanitation systems … % companies connected to sewage or comparable sanitation systems	the higher, the better
9	**On average, what is the number of incidents with untreated discharge of waste water to surface water every year?**		
	sewage capacity	… untreated discharge to surface water incidents per year	the lower, the better
10	**Is the effluent quality worse than the desired surface water quality of the receiving surface waters?**		
	effluent quality	effluent quality is not worse than desired surface water quality of receiving surface waters: yes/no *(if you have more waste water treatment plants, please, specify per plant)*	yes= bad, no= good
11	**On average, how many percent of the waste water effluent is reused for some purpose?**		
	reuse of effluent	… % of effluent reused	the higher, the better
		Surface- and groundwater system	
12	**What are the total costs of water quantity management, i.e. flood protection. Please, divide these costs by the population that is served by this water quantity management. If relevant, also specify the costs of non-sewage water quality management, i.e. ecological measures such as fish passages, etc. Please, divide these costs by the population that is served by this non-sewage water quality management.**		
	surface water management costs (quality & quantity including flood protection)	… EUR/person//year for water quantity … EUR/person//year for non-sewage water quality	the lower, the better
13	**What is the flood risk? I.e. what is the yearly chance of flooding times the damage in case of a flood.**		
	flood risk	1 flood per … year (flood chance) … EUR /flood incident (material damage) … deaths/flood incident	the lower, the better
14	**Are the water ways deep enough for ships the whole year through?**		

	water depth for ships	sufficient depth: yes/no	yes=good, no=bad
15	**Do recreational activities surpass the natural carrying capacity of the natural environment? I.e. does recreational use reduce species/habitat abundance or cause environmental pollution?**		
	balance recreational use and natural carrying capacity	balance: yes/no	yes=good, no=bad
16	**What is the condition of the river banks in general? Are they natural or artificial? Please, specify the km nature friendly river banks in relation to the total km of river banks in your city.**		
	natural river banks	… km nature friendly river banks/total km of river banks	the more, the better
17	**On average, what is the frequency of cooling water intake stops due to water shortages per year?**		
	frequency of cooling water intake stops due to water shortages	… stops/year	the fewer, the better
18	**On average, what is the frequency of thermal discharge stops and thermal pollution incidents?**		
	frequency of thermal pollution (i.e. high water temperature)	… thermal discharge stops/year … thermal incidents/year *(or: number of fish dying incidents/year)*	the fewer, the better
19	**Does fishing surpass the carrying capacity of the natural environment? I.e. is the fish population decreasing over the years due to fishing?**		
	future proof fisheries	over use or bad fishing techniques: yes/no	yes=good, no=bad
20	**What are the mining costs for the relevant resources in your city/region?**		
	mining costs**	… EUR/ton sand, gravel etc.	the lower, the better
21	**Is the water quality in your city sufficient for fish and swimming?**		
	water quality sufficient for fish and swimming?	sufficient: yes/no	yes=good, no=bad
22	**On average, what are the costs of ground water management (quantity & quality)? Only answer this question if the ground water management costs are NOT already included in your answer to question 12.**		
	ground water management costs (quantity & quality)	… EUR/person/year	the lower, the better
23	**Does the city suffer from high ground water levels leading to water nuisance, e.g. water in basements, water on the streets, etc? If yes, indicate which part of the city suffers from ground water nuisance.**		
	ground water nuisance (or	… % of the city with ground water nuisance	the lower, the better

	damage)	*(or: damage in EUR/year)*	
24	**Does the city suffer from salty ground water nuisance causing damage to gardens or crops? If yes, indicate which part of the city suffers from salty ground water nuisance.**		
	groundwater quality damage	… % of the city with salty water nuisance (or crop damage/year)	the lower, the better

* In the Netherlands one could also use the indicator ‘number of households with broken appliances’ in relation to the calcium level of drinking water. This will show differences between cities.

** If mining costs are low, then mining is apperantly easy, the transport distances are small.

CITY BLUEPRINTS VAN EINDHOVEN EN AMSTERDAM

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Notitie van 8 mei 2014

Inleiding

In het kader van een TKI project Urban Watermanagement Tools zijn de steden Eindhoven en Amsterdam vergeleken. Dit is ook gedaan in een recente studie over kosten en baten (Ruijgrok, 2014). In dit korte rapport vergelijken we de twee Nederlandse steden en wordt ook een vergelijking gemaakt met de milieu kosten baten analyse (MKBA).

Methodologie

De City Blueprint methodologie is gebaseerd op 24 kwaliteitsindicatoren (Tabel 1) en de methodologie is samengevat in een aantal publicaties (van Leeuwen et al., 2012; van Leeuwen and Chandy, 2013 en van Leeuwen, 2013) en wordt ook weergegeven in Tabel 2

Tabel 1. De 24 kwaliteitsindicatoren voor het stedelijk watersysteem (City Blueprint)

Water security	*Sanitation*	*Climate robustness*
1. Total water footprint	11. Safe sanitation	18. Local authority commitments
2. Water scarcity	12. Sewage sludge quality	19. Safety
3. Water self-sufficiency	13. Energy efficiency	20. Climate-robust buildings
Water quality	14. Energy recovery	*Biodiversity and attractiveness*
4. Surface water quality	15. Nutrient recovery	21. Biodiversity
5. Groundwater quality	*Infrastructure*	22. Attractiveness
Drinking water	16. Maintenance	*Governance*
6. Sufficient to drink	17. Separation of waste & stormwater	23. Management and action plans
7. Water system leakages		24. Public participation
8. Water efficiency		
9. Consumption		
10. Quality		

Tabel 2. Samenvatting van de City Blueprint methodologie.

doel	**quick-scan van de duurzaamheid van de stedelijke waterketen op basis van 24 indicatoren verdeeld over acht categorieën**
categorieën	1. waterzekerheid 2. waterkwaliteit 3. drinkwater 4. zuivering 5. infrastructuur 6. klimaatrobuustheid 7. biodiversiteit en aantrekkelijkheid van de woonomgeving 8. bestuur
gegevens	openbare gegevens of verkregen via specifieke vragenlijsten van de waterketenpartijen voor de lokale situatie. Indien afwezig worden regionale of nationale gegevens gebruikt.
scores	schaal 0 (serieus probleem) tot 10 (geen probleem)
	kwantitatief of kwalitatief met de mogelijkheid tot beoordeling door deskundigen
BCI	rekenkundig gemiddelde van de 24 indicatoren per stad
belanghebbenden	alle waterketenpartijen die vroeg in het proces dienen te worden betrokken
proces	interactief, met een coördinator per stad en een neutrale procesbegeleider en rapporteur

Inmiddels is een groot aantal steden beoordeeld en is ook een City Blueprint Action gestart in het kader van de European Innovation Partnership on Water en zijn 25 steden beoordeeld (http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions-ag041).

Resultaten

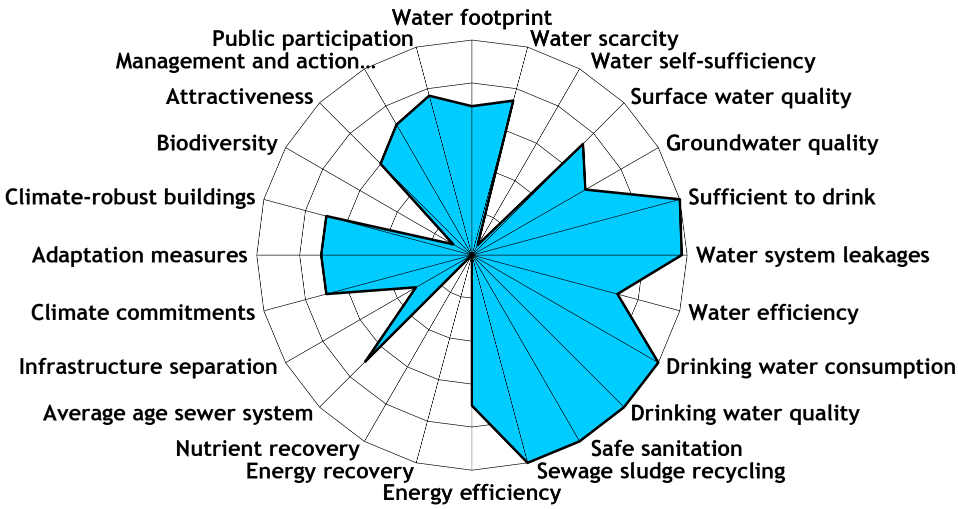
De City Blueprint van Amsterdam is eerder gepubliceerd (Van Leeuwen, 2013). De scores voor Eindhoven zijn ontleend aan de bijdragen van Brabant water en additioneel online literatuur onderzoek bij KWR. De resultaten voor de 24 indicatoren worden weergegeven in Tabel 3.

Tabel 3. City Blueprint scores voor Eindhoven en Amsterdam

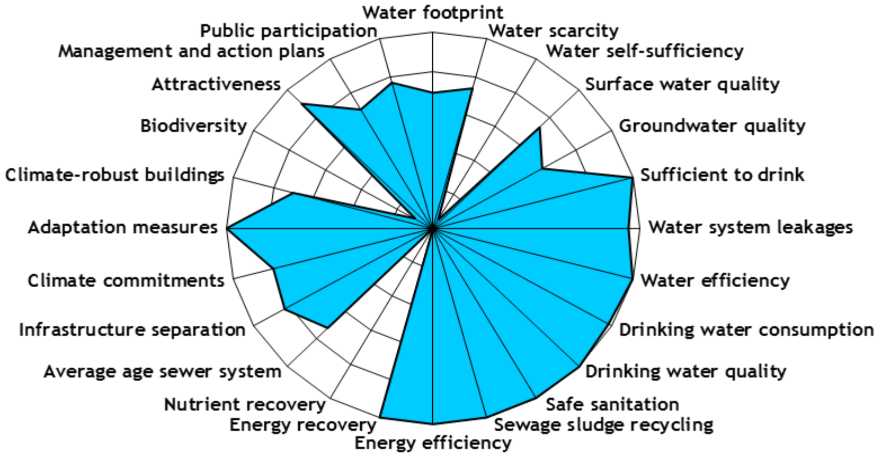
Nr	Indicator	Eindhoven	Amsterdam
1	Water footprint	6,9	6,9
2	Water scarcity	7,4	7,4
3	Water self-sufficiency	0,5	0,5
4	Surface water quality	7,3	7,3
5	Groundwater quality	6,1	6,1
6	Sufficient to drink	10	10
7	Water system leakages	9,8	9,5
8	Water efficiency	7	10
9	Drinking water consumption	10	9,8
10	Drinking water quality	10	10
11	Safe sanitation	10	10
12	Sewage sludge recycling	10	10
13	Energy efficiency	7	10
14	Energy recovery	0	10
15	Nutrient recovery	0	0
16	Average age sewer system	7	7,2

17	Infrastructure separation	3	8,3
18	Climate commitments	7	8
19	Adaptation strategies	7	10
20	Climate-robust buildings	7	7
21	Biodiversity	1	1
22	Attractiveness	6	9
23	Management and action plans	7	7
24	Public participation	7,7	7,7
	Blue City Index (BCI)	6,4	7,6

Omdat een aantal indicatoren een nationale grondslag hebben (indicatoren 1-5, 21 en 24), zijn de verschillen tussen Eindhoven en Amsterdam toch niet onaanzienlijk. Amsterdam heeft een BCI van 7,6 en Eindhoven een BCI van 6,4. Amsterdam scoort duidelijk beter op het vlak van water efficiency, energy efficiency, energy recovery, infrastructure separation en attractiviteit. Eindhoven is het afgelopen jaar minder aantrekkelijk geworden om te wonen. Dat blijkt uit de 15e editie van de Atlas voor gemeenten. Amsterdam staat op de eerste plaats en Eindhoven daalde naar plaats 17 op de woonaantrekkelijkheidsindex.

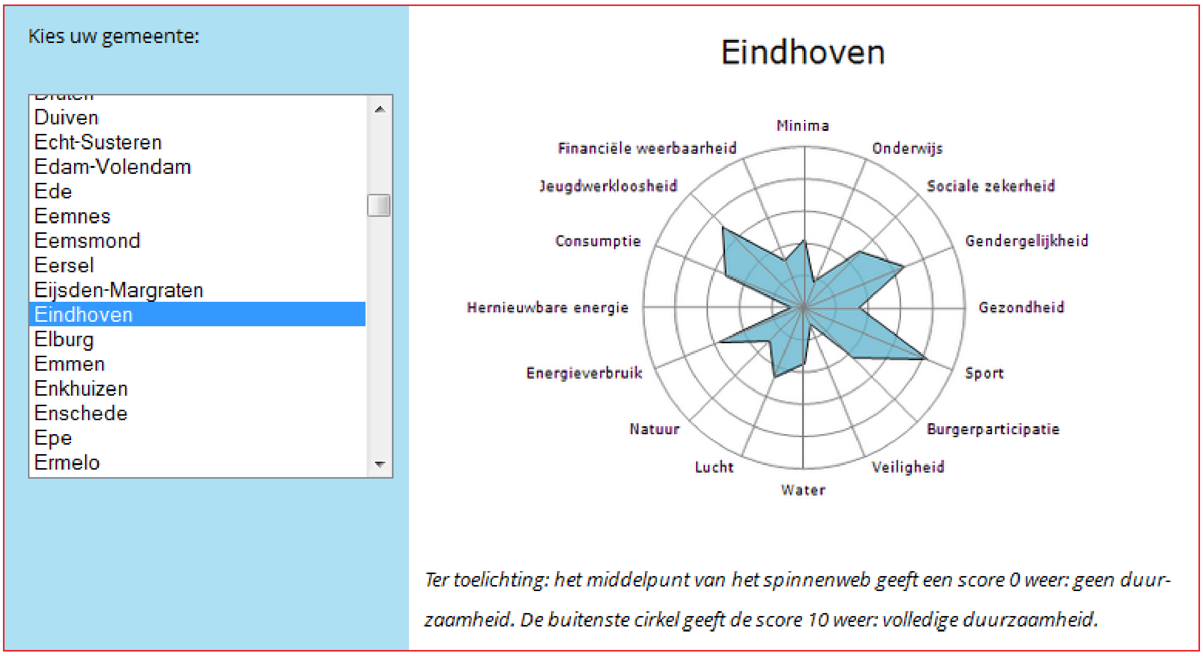


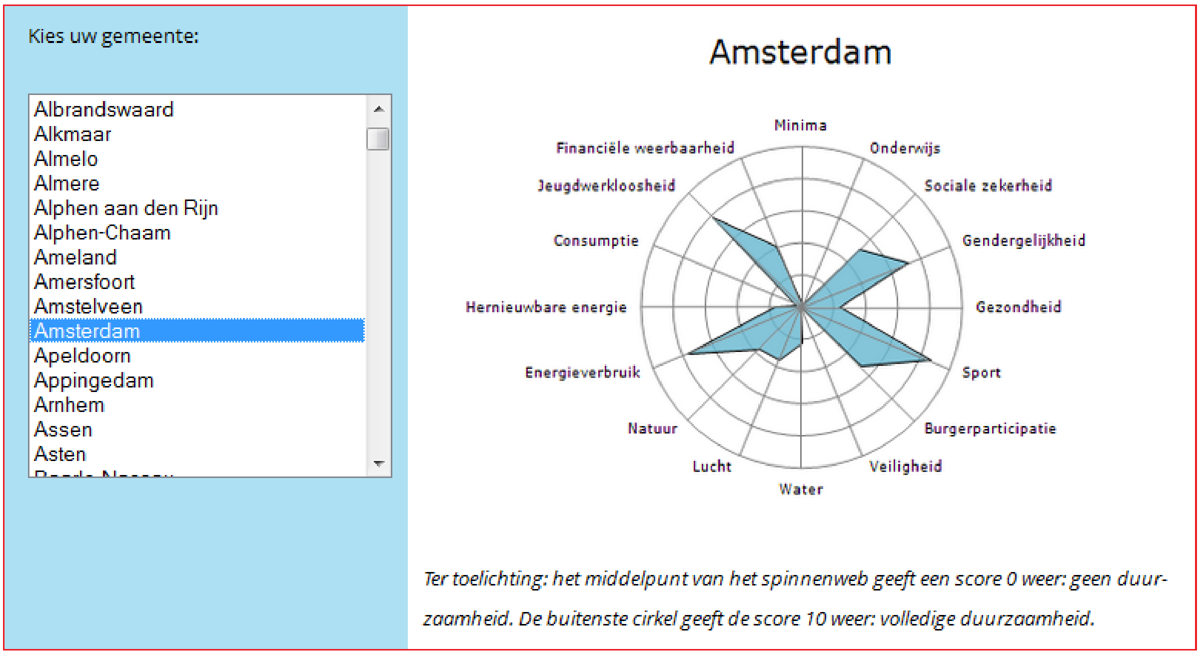
Figuur 1. De City Blueprint van Eindhoven.



Figuur 2. De City Blueprint van Amsterdam.

Wanneer een vergelijking wordt gemaakt met de informatie van de Gemeentelijke Duurzaamheidsindex (GDI; http://www.gdindex.nl/) dan kan geconstateerd worden dat Amsterdam en Eindhoven weinig verschillen. Op het gebied van water (indicator 9 van de GDI) scoorde Eindhoven met een 3,5 en Amsterdam met een score van 2,2. Het betreft hier de biologische kwaliteit oppervlaktewater, met als bron de Kader Richtlijn Water (2009).





Uit het rapport van Ruijgrok (2014), blijkt dat er op een aantal onderdelen verschillen bestaan. Opvallend was vooral het verschil in de kosten van de drinkwatervoorziening en waterbeheer, Deze zijn in Amsterdam fors duurder dan in Eindhoven, zoals blijkt uit indicator 1 (97 % duurder). Dit verschil is waarschijnlijk te verklaren doordat de drinkwatervoorziening voor Amsterdam gebaseerd is op rivierwater, dat getransporteerd wordt naar de duinen voor infiltratie en vervolgens weer getransporteerd wordt van de duinen naar de stad. In Eindhoven wordt gebruik gemaakt van diep grondwater.

Uit deze grove vergelijking van de (1) MKBA analyse, (2) de City Blueprint en (3) de GDI blijkt dat er geen grote verschillen tussen de steden zijn. Globaal zijn de verschillen misschien niet erg groot maar de verschillen zijn ook zeker niet onaanzienlijk als men in meer detail naar de onderliggende indicatoren kijkt. Dat geldt in principe zowel voor de MKBA, de City Blueprint als de GDI. Verschillen zullen verder toenemen als men voor alle indicatoren de beschikking zou hebben over lokale data. Nu is dit niet het geval voor een aantal indicatoren van de Blue City Index, omdat deze een nationale grondslag hebben (indicatoren 1-5, 21 en 24). Het steunt de zienswijze dat er grote behoefte is aan lokale informatie op het gebied van de stedelijke waterketen (Van Leeuwen, 2014).

Referenties

Ruijgrok, E.C.M. 2014. Naar een City Blue Print+ op basis van baten. Witteveen en Bos. Notitie NGN142-114-000.068.

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EIP Water. City Blueprints of 25 cities and regions.

Authors: Kees Van Leeuwen and Rosa Sjerps (KWR Watercycle Research Institute)

Summary

Cities are centres of creativity and innovation and the drivers of our economies (Dobbs, 2011 and 2012). Smart cities are water wise cities that take sustainability into account. Megatrends, e.g. population growth, urbanization, water use, water scarcity and flooding as a consequence of climate change, as well as water pollution, pose urgent water challenges in cities (Van Leeuwen, 2013; Figure 1). This interim report presents City Blueprints, i.e., baseline assessments of the sustainability of Urban Water Cycle Services (UWCS) for 25 cities and regions in 19 different countries, mainly in Europe. In a next City Blueprint report (May 2014), we hope to include another eight cities and update the report on the basis of further information.

The City Blueprint methodology has been developed as part of the institutional research of KWR Watercycle Research Institute in the context of Watershare®: sharing knowledge in the water sector (http://www.kwrwater.nl/watershare/). The methodology has been applied in the EU Research Project TRUST (Transitions to the Urban Water Services of Tomorrow; http://www.trusti.net/) and has further been elaborated as contribution to the European Innovation partnership on water (EIP Water), as part of the City Blueprint Action Group: http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions. In fact, much of the work has been done by colleagues in the cities who completed the City Blueprint questionnaires for the baseline assessment of their cities and regions.

Recently, the World Economic Forum (2013) identified the water supply crisis as one of the top five global risks for both the impact and likelihood. This is caused by the decline in the quality and quantity of fresh water combined with increased competition among resource-intensive systems, such as food and energy production. Safety is another issue and many cities are at risk (UN, 2012). The present City Blueprint interim report shows this for a number of cities and also confirms the findings of a previous publication for 11 cities. Cities vary considerably with regard to the sustainability of the UWCS (Van Leeuwen, 2013). The variability has been captured in the Blue City Index (BCI), the arithmetic mean of 24 indicators comprising the City Blueprint with a theoretical minimum score of 0 and a maximum score of 10. The indicators have been subdivided into eight broad categories, i. e. (1) water security, (2) water quality, (3) drinking water, (4) sanitation, (5) infrastructure, (6) climate robustness, (7) biodiversity and attractiveness and (8) governance. The BCI varied from 3.5 (Kilamba Kiaxi) to 8.0 (Hamburg and Malmö).

Although correlation coefficients (r) are no cause-effect relationships, cities with the best BCI are cities:

- With an active civil society expressed as Voluntary Participation Index (EFILWC, 2006; r=0.69)
- With high UWCS commitments (r=0.80)
- In countries with a high Gross Domestic Product (r=0.81)
- In counties with a high governance effectiveness (World Bank, 2012; r=0.84)

The most important result from this study is that the variability in sustainability among the UWCS of the cities offers excellent opportunities for short-term and long-term improvements, provided that cities share their best practices (Table 5 and Figure 15). Cities can learn from each other! The reports of the different cities and regions are presented in Annex 3 of this report. The main challenge now is to set up a Blue or Smart City network, to collaborate and to translate the baseline assessments into actions to improve the UWCS of cities in order to address the water challenges ahead of us. This report shows that even cities that currently perform well, can still improve their UWCS. Of course, this would depend on many other factors, such as socio-economic and political considerations, and is ultimately the responsibility of the cities themselves.

Overview

This interim report is an update from a previous report (Van Leeuwen and Marques, 2013) and has the following structure:

Chapter 1 provides the introduction to urban water cycle management.

Chapter 2 provides the scope, method, the data sources and the process of assessing the sustainability of UWCS.

Chapter 3 describes the results. It puts cities in their regional and/or national context and describes in more detail indicators for which it has not been easy to obtain adequate local information, i.e. water scarcity, surface water quality, biodiversity and groundwater quality and voluntary participation. For this information it was necessary to obtain regional or national data.

The discussion is provided in Chapter 4, whereas the main conclusions are presented in Chapter 5.The discussion is provided in Chapter 4, whereas the main conclusions are presented in Chapter 5.

Acknowledgements

We would like to thank all collaborative teams (see table below) involved the assessment of their cities and regions by completing the TRUST or City Blueprint questionnaire for the baseline assessment of the sustainability of UWCS. (Annexes 1 and 2). We would also like to thank our sponsors. This work has been carried out as institutional research of KWR Watercycle Research Institute in the context of Watershare®: sharing knowledge in the water sector (http://www.kwrwater.nl/watershare/) and has been sponsored by the Dutch drinking water industry (VEWIN). The City Blueprint methodology has been applied in the EU Research Project TRUST (Transitions to the Urban Water Services of Tomorrow; http://www.trusti.net/) and has further been applied in the context of the TKI Research Programme in the Netherlands (sponsored by Siemens, Brabant Water and Witteveen en Bos, the Netherlands). Within the TKI project, the City Blueprint has been extended by Witteveen en Bos (Elisabeth Ruigrok and Rob Nieuwkamer) with a societal cost benefit analysis. This was applied for the cities Amsterdam and Eindhoven (The Netherlands), and will be reported separately in February 2014. This interim report summarizes all the work done so far as contribution to the European Innovation partnership on water (EIP Water), as part of the City Blueprint Action Group: http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions.

Collaborative teams:

City	Contributions from	Institution
Algarve	Helena Lucas José Gascão Joaquim Freire Maria João Freitas António Jorge Monteiro	Aguas do Algarve LNEC (Laboratório Nacional de Engenharia Civil) LNEC Instituto Superior Técnico, Portugal
Amsterdam	Ingrid Heemskerk Paulien Hartog Brian Sewbaks	Waternet Waternet Waternet
Ankara	Rosa Sjerps Kees Van Leeuwen	KWR Watercycle Research Institute KWR Watercycle Research Institute
Athens	Christos Makropoulos	National Technical University
Bucharest	Gabriela Mercore	Apa Nova Bucuresti
Dar es Salaam	Kees Van Leeuwen Philipo Chandy	KWR Watercycle Research Institute Ministry of Water, Tanzania

Genova	Nicola Bazzurro	Mediterranea delle Acque
Hamburg	Thomas Giese Kim Augustin Niles-Peter Bertram David Schwesig	Hamburg Wasser Hamburg Wasser Hamburg Wasser IWW Water Research Centre
Ho Chi Minh City	Do Du Dung and Tran Huu Huy Joost van Buren Kees Van Leeuwen	Institute for Water Resources Planning (SIWRP) University of Wageningen KWR Watercycle Research Institute
Istanbul	Mehmet Patan and Erdem Görgün Aslihan Kerc	İstanbul Water and Sewerage Administration (İSKİ) Turkish Water Institute (SUEN)
Jerusalem	Avital Dror-Ehre Joshua Yeres	Water Advisory Division, Ministry of Energy and Water Government of Israel Hagihon Company Ltd
Kilamba Kiaxi	António Jorge Monteiro	Instituto Superior Técnico, Portugal
Lyon	Jean-luc Bertrand Krajewski Alexandre Bredimas Peter Easton	INSA de Lyon Strane innovation Water Resources Consultant
Maastricht	Hedwig van Berlo, Patrick Lutgens, Jelle Roorda and Rob Beckers Onneke Driessen Marco de Redelijkheid Jos Frijns and Kees Van Leeuwen	WML WML WBL WRO/City of Maastricht KWR Watercycle Research Institute
Malmö	Misagh Mottaghi Henrik Aspegren Annika Sevrell Rasmus Fredriksson, Tyke Tykesson and Per-Arne Nilsson	Department of chemical engineering, Lund University VA SYD VA SYD Malmö City Malmö City
Malta	Oronzo Dalioso	Paragon Europe
Manresa	Ricard Tomàs i Puig Josep Alabern	Aigues de Manresa Aigues de Manresa
Melbourne	John Chambers Ann Allworth and Lisa Hopkinson Kathryn Naylor and Jamie Ewert Francis Pamminger Natalie Portlock Andrew Allan, Amelia Tendler, Bridget Wetherall and Leah Wheatley Alan Watts	City West Water Department of Environment and Primary Industries Melbourne Water Yarra Valley Water Yarra Valley Water Office of Living Victoria Office of Living Victoria Office of Living Victoria South East Water
Oslo	Jadranka Milina Rita Ugarelli	Water and Sewerage Works SINTEF Building and Infrastructure
Pisa	Andrea Capelli Alma Serica	Autorita Idrica Toscana (Toscan Water Autorities) CUBIT Scarl
Reggio Emilia	Vittorio Di Federico	University of Bologna
Rotterdam	Daniel Goedbloed Kees Van Leeuwen	City of Rotterdam KWR Watercycle Research Institute
Scotland	Paul Jeffrey and Heather Smith George Ponton and Colin O'Neill	Cranfield Water Science Institute Scottish Water

Venlo	Hedwig van Berlo, Patrick Lutgens, Jelle Roorda and Rob Beckers Onneke Driessen Leon Stelten Ruud van Weert Jos Frijns and Kees Van Leeuwen	WML WML WBL WPM City of Venlo KWR Watercycle Research Institute
Zaragoza	Marisa Fernändez	ZINNAE-Zaragoza Innova en Agua y Energía

Introduction

The economic power of cities is enormous (Dobbs et al., 2011 and 2012). Smart cities (European Commission, 2013) should be water wise as the cost of water infrastructures is enormous and exceeds all other infrastructures (UNEP, 2013). It is estimated that a total of US$41 trillion is required to refurbish the old (in mainly developed country cities) and build new (mainly in the developing country cities) urban infrastructures over the period between 2005 and 2030. Over 50 per cent (US$22.6 trillion) would be required for water systems, US$9 trillion for energy, US$7.8 trillion for road and rail infrastructure, and US$1.6 trillion for air- and sea-ports (UNEP, 2013). In Europe it is crucial to link the activities of the European Innovation Partnership on water (EIP Water) with the EIP on Smart Cities and Communities. The management of freshwater resources and related services is of critical importance to healthy social, economic and political well-being of a society. Stresses exerted on the world's water resources by the increasing demand from growing populations with changing consumption patterns and the destruction of water quality from pollution as a result of poor environmental management, are placing water increasingly higher on the international agenda, including that of climate change (European Commission, 2011).

Effective water resource management and developments impacting on water resources are recognised as key components of environmentally sustainable development. The negative consequences of poor water resource management on socio-economic development are more frequently arising. This is clearly apparent in the agricultural and other water-sensitive industries. However industries where water is less evident in the supply chain, and even other sectors such as energy, are becoming increasingly aware of the risks and consequences associated with a potentially unreliable water resource (UNEP, 2007; 2030 Water Resources Group, 2009; African green city index, 2011).

The European Union (EU), through the European Commission (EC) and the EU Member States, has made a significant contribution to the international debate on the impending world water crisis and the measures needed to address it. Their support has contributed to efforts at the international level with other state actors, through the UN system and in inter-ministerial councils, to promote new initiatives in water resource management (e.g. European Commission, 2011; European Commission, 2012a). The Blueprint to Safeguard Europe's Water (European Commission, 2012b) will be the EU policy response to these challenges. It aims to ensure good quality water in sufficient quantities for all legitimate uses. The challenges will predominantly reside in cities (Figure 1; European green city index, 2009; Engel *et al.*, 2011).

Changes in urbanization, demography, including the aging population, socio-economic factors, climate change, biodiversity, energy use, water supply and consumption, as well as ageing infrastructures for e.g. water supply, water distribution and water treatment (UN, 2012; Ernstson *et al.*, 2010; Charlesworth, 2010; Cohen, 2007; Brown, 2009; Deltares, 2009) ask for a thorough understanding of the various possibilities to build towards a sustainable water cycle. Different scenarios to improve urban water supply, in the context of already well developed and equipped cities, have to be evaluated in respect to different aspects of sustainability, i.e., efficient use of water, energy and non-renewable resources, climate change, safety (adaptation strategies related to flooding and water scarcity), biodiversity, green space, recreation, human and environmental health, public participation, compliance to (future) legislation, transparency, accountability and costs (Frijns *et al.*, 2009; Verstraete *et al.*, 2009).

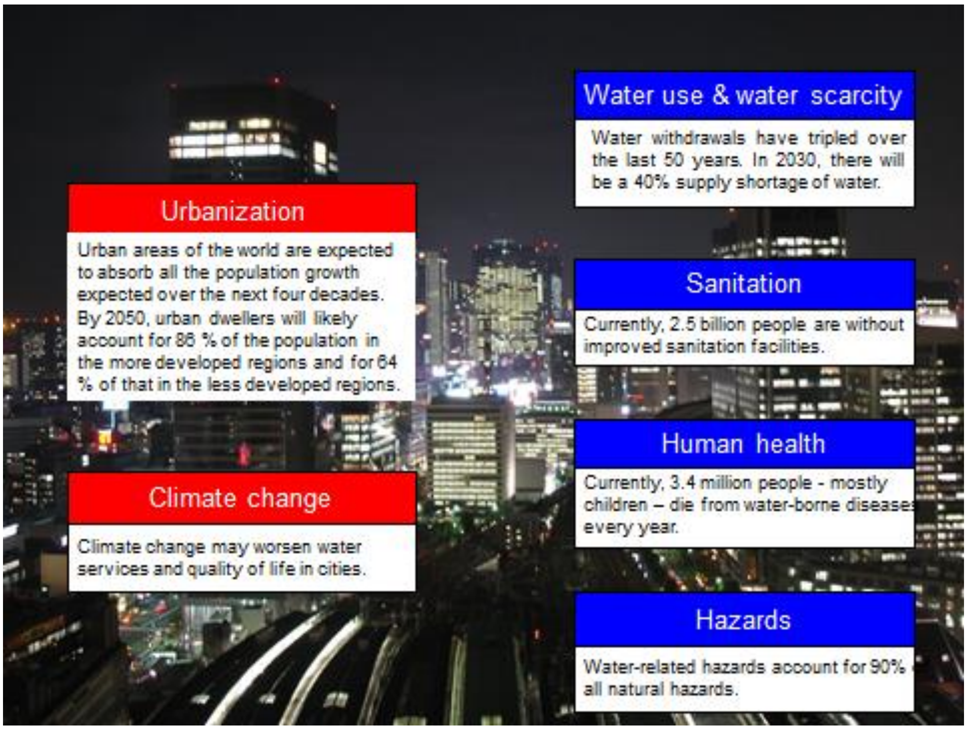


Figure 1. Megatrends pose urgent challenges in cities (Van Leeuwen, 2013).

The main objective of the City Blueprint action under the EIP Water is to support regions, cities, water authorities and utilities in Europe in formulating and implementing appropriate urban water governance actions in order to enhance urban water cycle services. We aim to deliver knowledge to support urban water cycle services (UWCS) towards a sustainable and low-carbon water future without jeopardising service quality. We hope to do this through research that drives innovations in governance, modelling concepts, technologies, decision support tools, and novel approaches to integrated water, energy, and infrastructure asset management. There is no single or clear pathway for the adoption of sustainable practices for water utilities, cities, or any other organization involved in UWCS. Cities are the main problem holders and also need to play a key role in defining long-term goals and action plans for sustainable UWCS. In the context of this action it has been decided to obtain data from contact persons in cities and regions in order to enable a quick scan of the sustainability of UWCS. The quick scan is a baseline assessment which:

- Provides stakeholders in cities and regions with a basic insight in the current status of the sustainability of their UWCS;
- Enables stakeholders to internally reflect upon the current status in terms of possible consequences for future UWCS management;
- Enables stakeholders to share the results with other colleagues, to discuss potential improvements and to learn from each other's experiences.

Materials and methods

Cities and regions

In this report the following cities, regions and countries are included: Algarve (ALG, Portugal), Amsterdam (AMS, Netherlands), Ankara (ANK, Turkey), Athens, (ATH, Greece), Genova (GEN, Italy), Hamburg (HAM, Germany), Ho Chi Minh City (HCM, Vietnam), Istanbul (IST, Turkey), Kilamba Kiaxi (KIL, Angola), Lyon (LYO, France), Maastricht (MST, Netherlands), Malmö (MLM, Sweden), Malta (MLT, Malta), Manresa (MAN, Spain), Melbourne (MEL, Australia), Oslo (OSL, Norway), Pisa (PIS, Italy), Reggio Emilia (REG, Italy), Rotterdam (ROT, Netherlands), Scotland (SCO, United Kingdom), Venlo (VEN, Netherlands), Zaragoza (ZAR, Spain).

Scope of the analysis

Urban water management is complex. It has a wide scope and many stakeholders are involved. Therefore, the baseline assessment of cities and regions needs to reflect this and cover a broad range of aspects such as water security, water quality, drinking water, sanitation, infrastructure, biodiversity and attractiveness, as well as governance. Sustainability assessment of urban water cycle services includes the main dimensions of social, environmental, economic and the supporting dimensions of assets and governance sustainability (Table 1).

Table 1. Objectives and assessment criteria of the UWCS sustainability dimensions (Van Leeuwen and Marques, 2013).

Dimension	Objectives	Assessment criteria
Social	S1) Access to urban water services S2) Effectively satisfy the current users' needs and expectations S3) Acceptance and awareness of UWCS	S11) Service coverage S21) Quality of service S22) Safety and health S31) Willingness to pay
Environment	En1) Efficient use of water, energy and materials En2) Minimisation of other environmental impacts	En11) Efficiency in the use of water (including final uses) En12) Efficiency in the use of energy En13) Efficiency in the use of materials En21) Environmental efficiency (resource exploitation and life cycle emissions to water, air and soil)
Economic	Ec1) Ensure economic sustainability of the UWCS	Ec11) Cost recovery and reinvestment in UWCS (incl. cost financing) Ec12) Economic efficiency Ec13) Leverage (degree of indebtedness) Ec14) Affordability

Governance	G1) Public participation G2) Transparency and accountability G3) Clearness, steadiness and measurability of the UWCS policies G4) Alignment of city, corporate and water resources planning	G11) Participation initiatives G21) Availability of information and public disclosure G22) Availability of mechanisms of accountability G31) Clearness, steadiness, ambitiousness and measurability of policies G41) Degree of alignment of city, corporate and water resources planning
Assets	A1) Infrastructure reliability, adequacy and resilience A2) Human capital A3) Information and knowledge management	A11) Adequacy of the rehabilitation rate A12) Reliability and failures A13) Adequate infrastructural capacity A14) Adaptability to changes (e.g. climate change Adaptation) A21) Adequacy of training, capacity building and knowledge transfer A31) Quality of the information and of the knowledge management system

These criteria were developed in TRUST (Van Leeuwen and Marques, 2013). The 24 indicators for the City Blueprints have been selected based on a literature study that covered scientific publications, a variety of national and international policy documents on several approaches to assess the sustainability of UWCS, i.e., water footprints (Hoekstra and Chapagain, 2007; Mekonnen and Hoekstra, 2011), urban metabolism (e.g. Barles, 2010), ecosystem services (e.g. Costanza *et al.*, 2002), and indicator-approaches (e.g. Van de Kerk and Manuel, 2008; European green city index, 2009). Details are provided in Annex 1 and several publications (Van Leeuwen *et al.*, 2012; Van Leeuwen and Chandy, 2013; Van Leeuwen, 2013).

Requirements

The following requirements were established for the calculation of the City Blueprint:

- Scope: the baseline assessment should comprise: water security, water quality, drinking water, sanitation, infrastructure, climate robustness, biodiversity and attractiveness, as well as governance.
- Data availability: data must be easily obtainable.
- Approach: a quantitative approach is the preferred option in which expert panel scores can also be included.
- Scale: indicators need to be scored on a scale between 0 (very poor performance which requires further attention) to 10 (excellent performance which requires no additional attention).
- Simplicity: calculations and scoring of the indicator values need to be relatively easy.

- Comprehensibility: results need to be interpreted and communicated relatively easily, not only to experts but to politicians and the public too, preferably in one graphic image such as a spider web, without the need for an in-depth knowledge of the applied methodology.

- Workability: data collection, further selection, calculations and graphical representation of the results need to be doable, i.e. to be completed in about 3 days.

Data and calculations

Detailed information about the methodology, sources of information and calculations for each of the 24 indicators are provided in previous publications (Van Leeuwen *et al.*, 2012; Van Leeuwen and Chandy, 2013; Van Leeuwen, 2013) and Annex 1. A summary is provided in Figure 2. In this report, the lack of city-specific information forced us to use regional or national sources of information. This was particularly relevant for information related to surface water quality, groundwater quality and biodiversity of aquatic ecosystems. Furthermore, Indicator 12 (Annex 1) focuses on the percentage of total sewage sludge that is recycled (thermally processed or applied in agriculture) and indicator 16 reflects the average age of the infrastructure for wastewater collection and distribution. This is a rough estimate as maintenance of sewer systems is dependent amongst other things on the soil type, the pipe construction materials, the soil type, pipe depth, pipe thickness and bedding conditions (Ugarelli *et al.*, 2009). Furthermore indicator 19 covers climate change adaptation strategies, or in short: “adaptation strategies”.

The requirements of scale and comprehensibility necessitated the transformation of the original data (Van Leeuwen *et al.*, 2012 and Van Leeuwen and Chandy, 2012). For instance, the total water footprint of the Netherlands is 1466 m^3/yr/cap and slightly above the world average of 1385 m^3/yr/cap (Mekonnen and Hoekstra, 2011). This value was transformed using min max normalization using data from the Democratic Republic of Congo (552 m^3/yr/cap) as minimum and Niger (3519 m^3/yr/cap) as maximum value, respectively. These data are provided in Appendix VII of Mekonnen and Hoekstra (2011). The value for the Netherlands thus becomes (1466-552)/3519-552) = 0.308. In order to transform this into a ‘concern score’ on a scale of 0-10, we arrived at a score of (1-0.308) x 10 = 6.92 for the Netherlands. In other words, based on the information provided by Mekkonnen and Hoekstra (2011), the total water footprint in the Netherlands is about average and this is reflected in a score of 6.9.

The voluntary participation index (by country), was not available for the cities outside the European Union (EFILWC, 2006). Therefore only estimates for these countries could be provided. These estimates were obtained from the relation between the internet use in 2003 (%) and the voluntary participation index (VPI) in 2004 (EFILWC, 2006) as described in Van Leeuwen and Chandy (2012) and Chapter 3 of this report.

If, despite the attempts of the partners in the cities and regions, the search for local, regional or national data in public sources, no input data could be provided for the calculations of the indicator values, estimates based on expert judgements or ‘educated guesstimates’ have been used.

Goal	Baseline assessment of the sustainability of UWCS of cities
Indicators	Twenty-four indicators divided over eight broad categories: 1.Water security 2.Water quality 3.Drinking water 4.Sanitation 5.Infrastructure 6.Climate robustness 7.Biodiversity and attractiveness 8.Governance
Data	Public data or data provided by the (waste) water utilities and cities based on a questionnaire for UWCS
Scores	0 (concern) to 10 (no concern) (Blue is good)
BCI	Arithmetic mean of 24 indicators which varies from 0 to 10 (in parentheses)
Stakeholders	Water utility, waste water utility, water board, city council, NGOs
Process	Interactive with all stakeholders involved early on in the process

Figure 2. Summary of the City Blueprint assessment methodology and process.

The process

Integration is most successful when there is a process of interaction rather than a one-way delivery of knowledge on the doorstep of the policy maker (Ison *et al.*, 2011). Rather than collecting information ourselves, as in the case of the cities of Rotterdam and Dar es Salaam, the stakeholders (representatives of municipalities, water utilities, wastewater utilities and water boards) were asked to complete a questionnaire (Appendix 1) in an interactive manner. This interactive multi-stakeholder approach to problem formulation (Van Leeuwen, 2007), assessment and evaluation of UWCS as applied for the cities of Venlo and Maastricht (Van Leeuwen and Frijns, 2012; Van Leeuwen *et al.*, 2012) was much more effective, as it underlined the connectivity between the technical, economic and socio-political processes (Godden *et al.*, 2011; Ison *et al.*, 2011; Van Leeuwen and Chandy, 2012). Therefore, this interactive approach has been used for almost all cities.

Results

The context of cities and regions

The goods-and-services that cause the highest environmental impacts through their life cycles have been identified as housing, food and mobility (UNEP, 2007). For food and beverages, the majority of environmental impacts are related to agricultural or industrial production activities. Agriculture accounts for more than 70 percent of global water use. This, together with land degradation, decreases agricultural productivity, resulting in lower incomes and reduced food security. Freshwater bodies have a limited capacity to process the pollutant charges of the effluents from expanding urban, industrial and agricultural uses. Water quality degradation can be a major cause of water scarcity. Excessive use of nutrients and pesticides in agriculture may harm the hydrologic system because runoff can not be filtered or slowed down before being distributed into other bodies of water. As a result, the amount of water that infiltrates is decreased and the amount of storm water runoff increases. This then creates more problems such as erosion, flooding, and destruction of habitat. Water security and environmental quality (Figure 3) are among the important factors that provide the context of cities and regions related to UWCS.

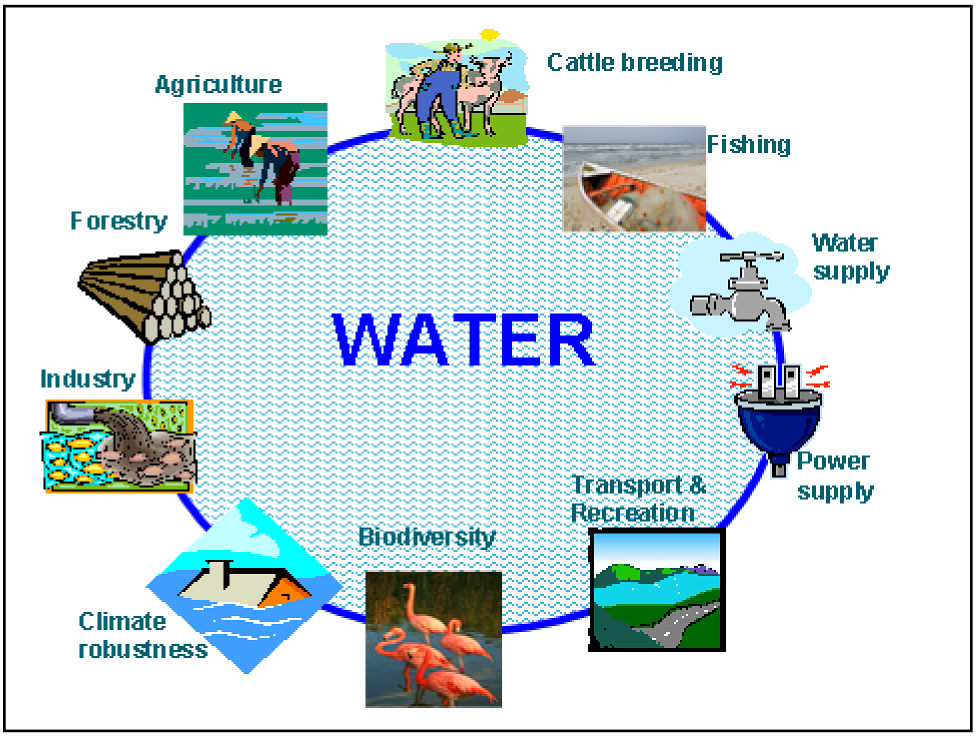


Figure 3. Urban water cycle services demonstrate that competing needs for water lead to trade-offs in practice (Van Leeuwen et al., 2012).

This is the reason why information was gathered on water scarcity, surface water quality, biodiversity of surface water and (shallow) groundwater quality. As voluntary participation of the civil society is crucial for the sustainability of cities (European green city index, 2009), this and the other aspects will be described in more detail below.

Water scarcity

Water scarcity has been addressed in many policy papers of the United nations (UN), the Food and Agricultural Organization (FAO), the European Commission and reports from industry and the European Environment Agency (EEA). There are a variety of methods to illustrate water scarcity and water exploitation. The EEA has used the water exploitation index (WEI), which is the annual total water abstraction as a percentage of available long-term freshwater resources (Figure 4). The warning threshold, which distinguishes a non-stressed area from a water scarce region, is around 20 %, with severe scarcity occurring where the WEI exceeds 40 %. However, this indicator does not fully reflect the level of stress upon local water resources: this is primarily because the WEI is based on annual data and cannot, therefore, account for seasonal variations in water availability and abstraction.

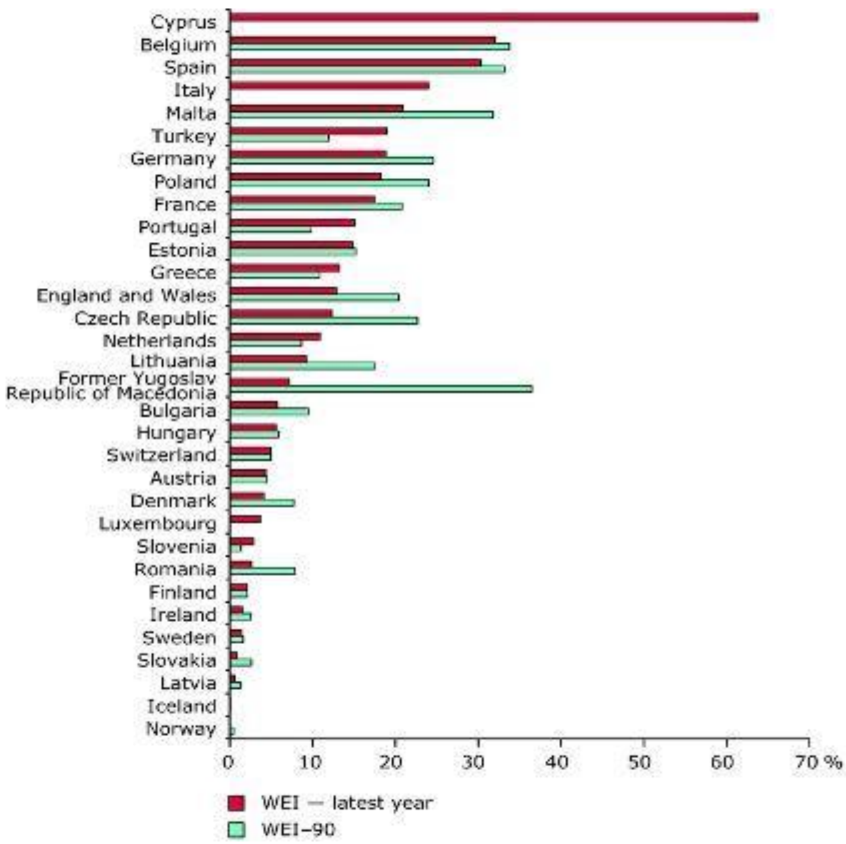


Figure 4. The water exploitation index (WEI) according to the EEA (2011).

Similar information is provided in the Aquastat database of FAO (2012). The FAO Aquastat database provides the total freshwater withdrawal as percentage of the actual renewable water resources (ARWR) per country as indicator for the pressure on water resources. For Germany, Italy and Spain these values are relatively high, respectively 21, 23.7 and 29 % (Figure 4).

The Water Footprint Network (WFN, 2012) provides water statistics for nations. The water footprint of a nation is defined as the total amount of water that is used to produce the goods and services consumed by the inhabitants of the nation. Since not all goods consumed in one particular country are produced in that country, the water footprint consists of two components: (1) The internal water footprint, i.e. the water use inside the country, and (2) The external water footprint, i.e. the water use in other countries. The traditional water-use statistics show the water supply per sector (domestic, agriculture, industry). The approach has always been supply and producer oriented. The water footprint concept has been introduced to have a demand and consumer oriented indicator as well, including not only the water used within the country but also the virtual water import. The nature of the WFN approach is totally different from the traditional water statistics as provided by FAO. In the analysis of cities and regions we have used both approaches, i.e. the information from WFN (Indicators 1-3 in Annex 1b) as well as the information from the FAO Aquastat database (see Annex 3).

Another approach may be to look at the number of months during the year in which the blue water footprint exceeds blue water availability for the world's major river basins, based on the period of 1996–2005 (Hoekstra et al., 2012):

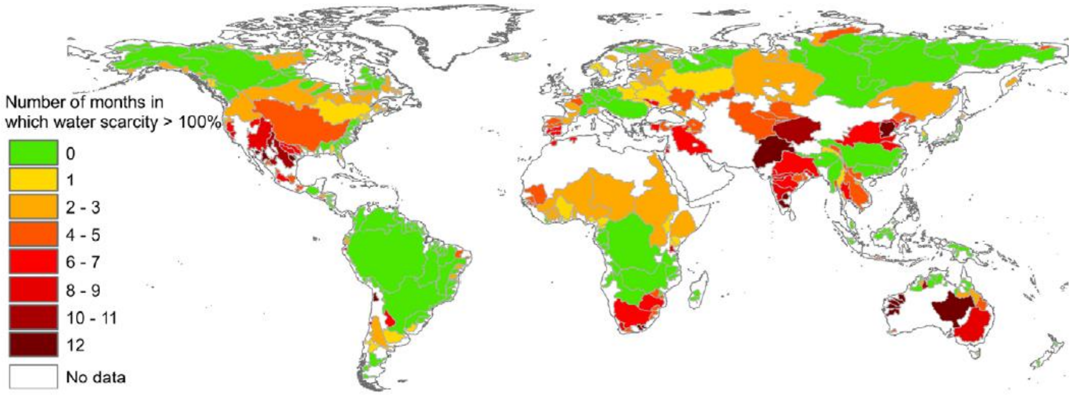


Figure 5. Number of months during the year in which the blue water footprint exceeds blue water availability for the world's major river basins, based on the period of 1996–2005. Blue water availability refers to natural flows (through rivers and groundwater) minus the presumed environmental flow requirement (Source: Hoekstra et al., 2012).

Surface water quality

Many different physical, chemical, and biological parameters can be used to measure water quality. Unfortunately, this information is neither easily accessible nor available for most countries. The 2010 Environmental Performance Index (EPI) Water Quality Index (WQI) uses three parameters measuring nutrient levels (dissolved oxygen, total nitrogen, and total phosphorus) and two parameters measuring water chemistry (pH and conductivity). These parameters were selected because they cover issues of global relevance (eutrophication, nutrient pollution, acidification, and salinization) and because they are the most consistently reported. The data were taken from the United Nations Global Environmental Monitoring System (GEMS) Water Programme, which maintains the only global database of water quality for inland waters, and the European Environment Agency's Waterbase, which has better European coverage than GEMS. These national data were used as input for the calculation of the scores for surface water quality (indicator 4 of the City Blueprint; Annexes 1 and 2).

Biodiversity of surface water

The decline in the quantity and quality of surface water is impacting aquatic ecosystems and their services. Based on the very limited responses on the questionnaires for biodiversity it was decided to use information collected by the EEA for the assessment of the biodiversity of fresh surface waters. This is basically information summarized at the regional level (Figure 6). Based on Figure 5, the following scoring was applied: >90% = score 1; 70-90 % score 2; 50-70% score 4; 30-50% score 6; 10-30% score 8; <10% score 10; No information was available for Oslo, but an expert judgement estimate of 6 has been given. The scores for cities in other countries have been obtained from the information on effects on ecosystems from the environmental performance index (2010).

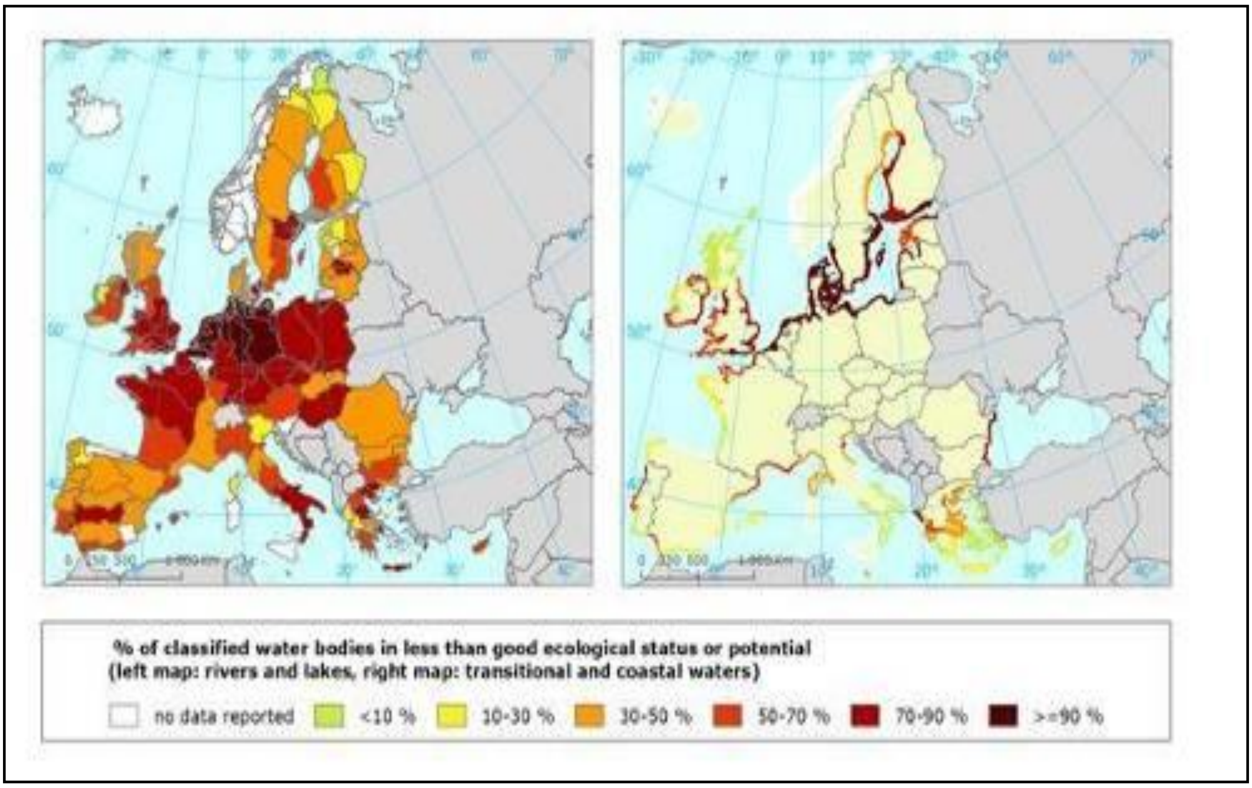


Figure 6. Ecological status of water bodies in Europe according to the European Environment Agency (EEA).

Groundwater quality
The similar lack of information provided in the responses on the questionnaires also necessitated the use of information collected by the EEA for the assessment of the shallow groundwater based on the data provided in their Water Framework Directive (WFD) groundwater viewer:
http://www.eea.europa.eu/themes/water/interactive/soe-wfd/wfd-ground-water-viewer

Governance and voluntary participation
According to the Dutch water sector (http://www.dutchwatersector.com/web/governance), good management of water resources- universally identified as a key aspect of poverty reduction, agriculture and food security – has proven, in practice, as difficult to achieve as it is eagerly sought. According to the UNDP (2004), "water governance encompasses the political, economic and social processes and institutions by which governments, civil society, and the private sector make decisions about how best to use, develop and manage water resources". Questions 28-35 of the TRUST questionnaire (Annex 1) encompass governance aspects. We have also added another indicator (public participation; indicator 24) and used national data for the calculation of this indicator based on the data provided by EFILWC (2006). The reason for this was the striking relation between the ranking of cities based on the European green city index (2009) and the voluntary participation index. It basically shows how important civil society is (Figure 7). People matter and this is probably also relevant for UWCS. One quote from this report summarizes it adequately: "The individual decisions of cities' inhabitants are, collectively, more powerful than their governments' ability to intervene". For most European countries the VPI has been provided in the report of EFILWC (2006), but for other countries the VPI was estimated based on the internet connectivity as presented in Figure 8.

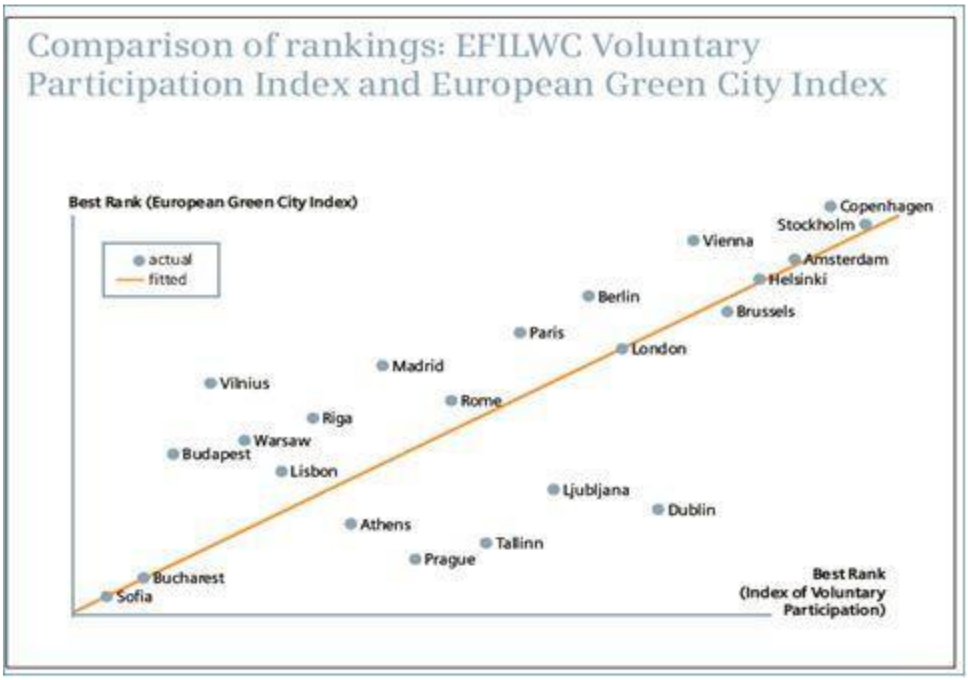


Figure 7. The relation between the index of voluntary participation (VPI) and the ranking according to the European green city index (2009).

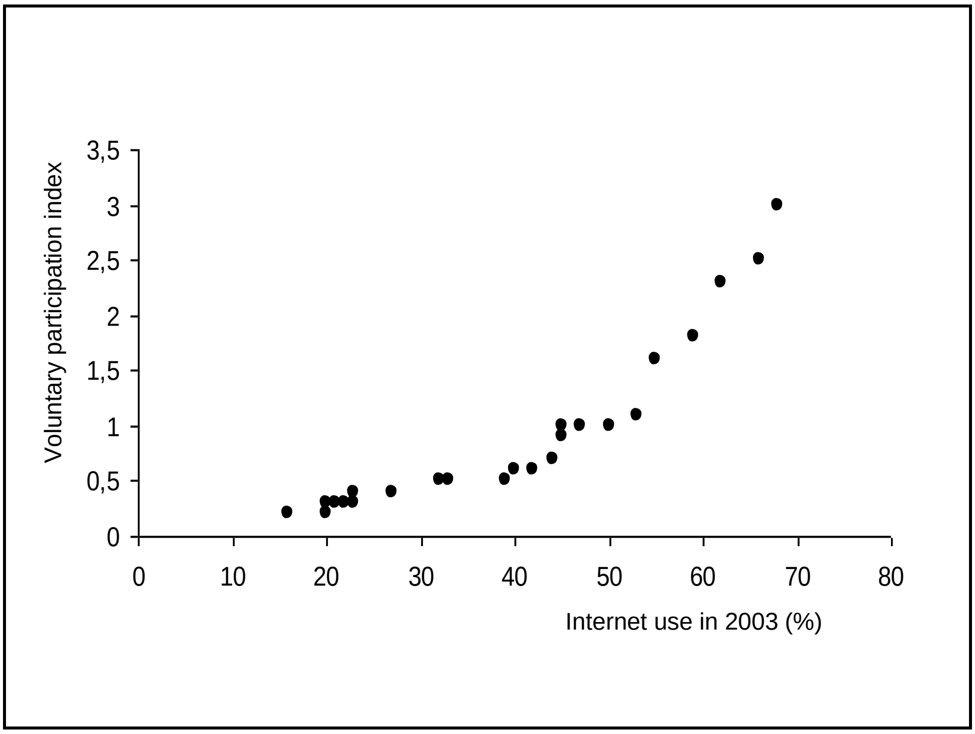


Figure 8.The relation between internet use and the VPI (Van Leeuwen and Chandy, 2012).

Comparison of UWCS of cities and regions

The information from the City Blueprint questionnaire (Annex 2) has been used to make short reports of the cities and regions. These reports of the cities and regions are presented in Annex 3.

Drinking water

Detailed information has been provided for 11 cities via the TRUST questionnaire (Annex 1) and has been adequate to score most parameters for these cities (Van Leeuwen and Marques, 2013). The most extensive evaluation was carried out for the city of Melbourne (Annex 3). In general, the water quality and population coverage for drinking water services of the European cities was excellent. Prices varied from € 0.45 (bulk water in Algarve) to €1.77 in Hamburg (excl. VAT). Drinking water consumption varied considerably. In Hamburg and Amsterdam the consumption was about 50 m^3 per person per year, whereas the consumption in Algarve was about three times higher (146 m^3 per person per year). The asset turnover ratio could not be reported for all cities and for those cities for which this information was available it varied from 0.15 (Oslo) to 3.37 (estimate for Reggio Emilia). Knowledge about acceptance of alternative water resources was absent in most cases. The mains average age for the 11 cities studied in the TRUST project (Van Leeuwen, 2013) varied from 11 (Algarve) to 55 year in Oslo and Reggio Emilio, although the latter figure is a rough estimate. The mains failures varied from 0.46 (Algarve) to 117.5 (Reggio Emilia).

Water consumption and water scarcity

As presented in the materials and methods section, different parameters can be used to describe water use and water scarcity. Some of these indicators are presented in Table 2 and Figures 4, 5 and 9. Please note that all these parameters, except drinking water consumption, are based on data for countries and not for cities.

Table 2. Indicators for water use and water stress for countries and drinking water consumption in cities/regions as reported in Van Leeuwen and Marques (2013).*

Indicator	ALG	ATH	REG	AMS	HAM	OSL	SCO	BUC	ROT	KIL	DAR
FAO-TWW per capita (m^3/year)	812	841	790	639	391	622	213	320	639	43	145
WFN-TWF of national consumption per capita (m^3/year)	2505	2338	2303	1466	1426	1423	1258	2297	1466	1589	1026
FAO-TWW as % of ARWR	12.3	12.7	23.7	11.7	21	0.77	8.82	3.25	11.7	0.43	5.38
Drinking water consumption (m^3 per capita per year)	146	106	59	50	53	124	97	58.7	45	36	68

**TWW= Total Water Withdrawal; TWF=Total Water Footprint; ARWR = Annual Renewable Water Resources.*

For the comparison of countries and cities also the water exploitation index as shown in Figure 4 is important. Another representation of the WEI is given in Figure 9.

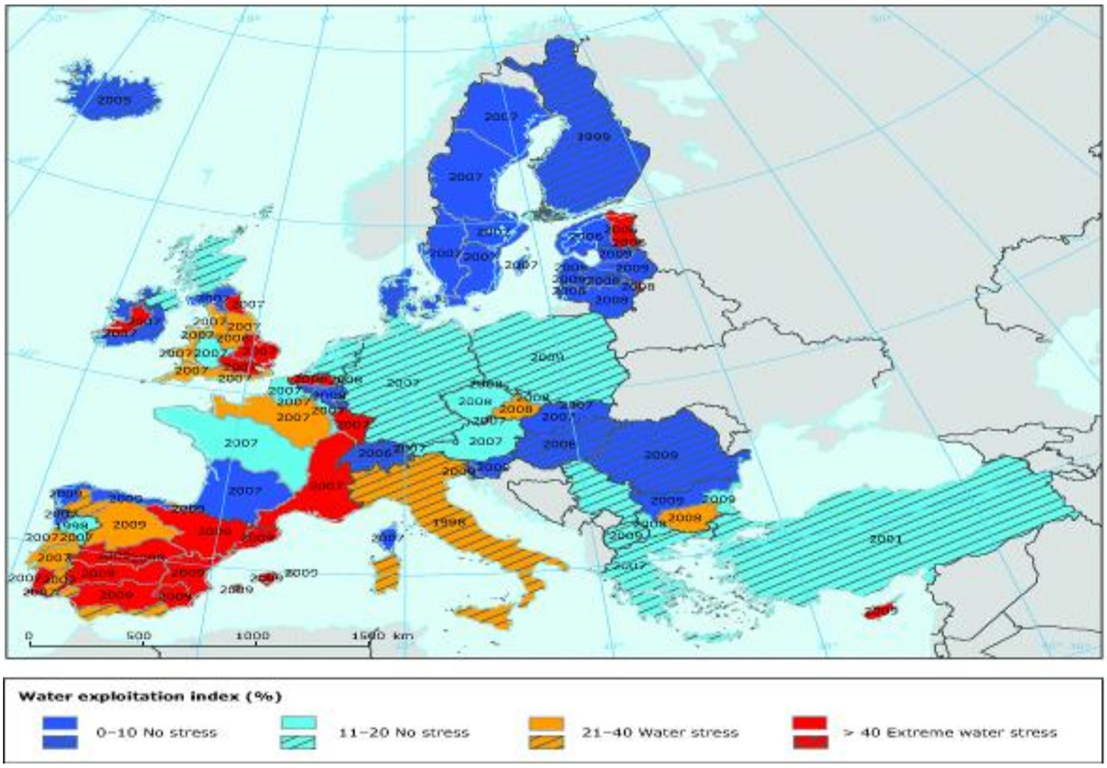
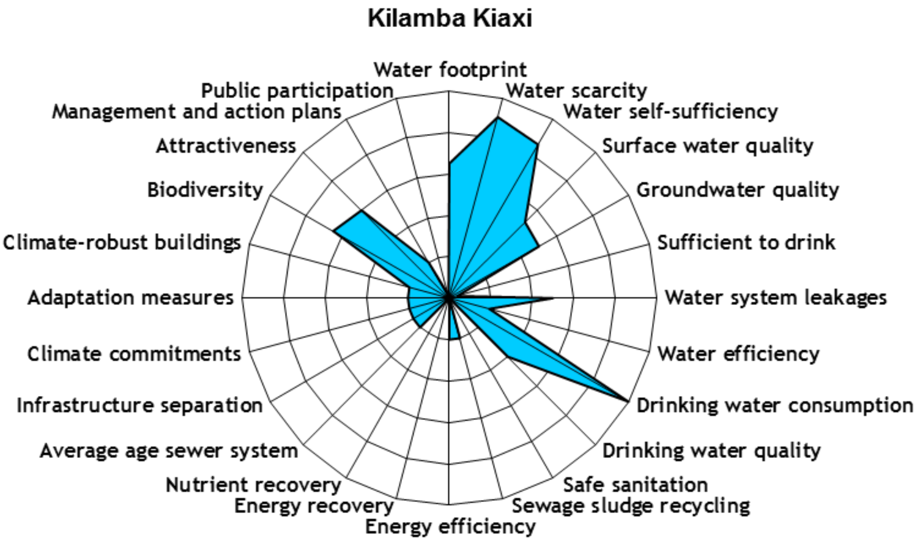


Figure 9. The water exploitation index (%) in Europe (source: EEA).

Waste water
For the waste water services in Europe, the population coverage varied from 80 % (Pisa) to about 100 % for Oslo, Malmo and Malta). Waste water treatment remains a serious challenge for Dar es Salaam, Ho Chi Minh city and Kilamba Kiaxi. Most of the systems were collection, transport and treatment systems. Energy recovery from waste water takes place in all European cities except the cities in Algarve, Pisa and Bucharest. It is absent in cities in developing countries. Nutrient recovery is an exception and only takes place in Hamburg, Lyon, Manresa, Malmo and Reggio Emilia. Unfortunately, no information is available for Scotland for both energy and nutrient recovery from waste water. Therefore, these indicators have been scored with 0. For the 11 cities studied in the TRUST project (Van Leeuwen and Marques, 2013), the total energy costs varied from € 0.7 million (covering 325,000 connections) to € 23.6 million in Scotland (covering 2,460,000 connections). The energy costs per connection varied from € 0.44 (Oslo) to € 19.6 (Athens).

Most cities process their sewage sludge thermally, but some cities in e.g. Scotland, the city of Jerusalem, Reggio Emilia, Manresa, Genova, and the cities in Algarve, apply major volumes their sewage sludge in agriculture. In some places in Scotland and in the Algarve small fractions of the sewage sludge is going into landfill. In Bucharest, Istanbul all sewage sludge is going into landfill. The average age of the sewer system varied from 11 (Algarve) to 55 years (Oslo). The number of sewage blockages (in the 11 cities as studies in the TRUST project; Van Leeuwen and Marques, 2013) varied from 0.5 (per 100 km) in Algarve to 577 in Bucharest. The separation (lengths of sanitary and stormwater sewers divided by the total length of the sewer system, including the combined sewers) showed a large variation. It varied from 0% for Algarve to 100 % for Ankara, Jerusalem and Melbourne.

City Blueprints
A simple diagram has been made to highlight the most important features of the UWCS in cities. We have called this diagram the City Blueprint (Van Leeuwen *et al.*, 2012) in line with the European Commission's "Blueprint to Safeguard Europe's Water Resources" (European Commission, 2012b). The information of the questionnaires has been transformed into scores for 24 indicators, comprising the so-called City Blueprint (Van Leeuwen., 2013) The results for all cities and regions of TRUST are presented in Annex 3. Examples of eight cities with increasing BCI values are presented in Figure 10.



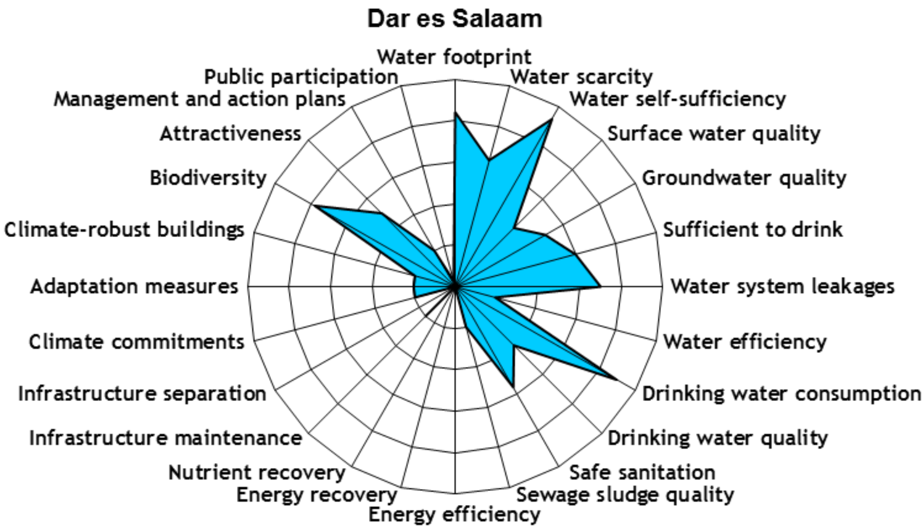
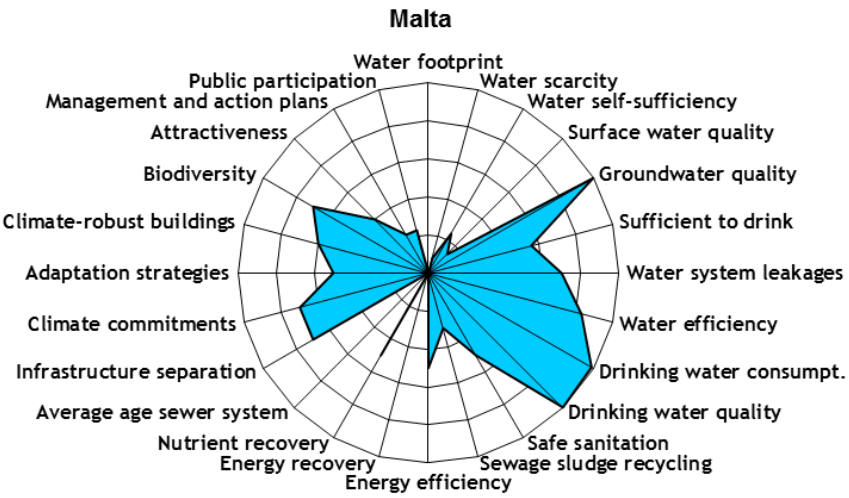
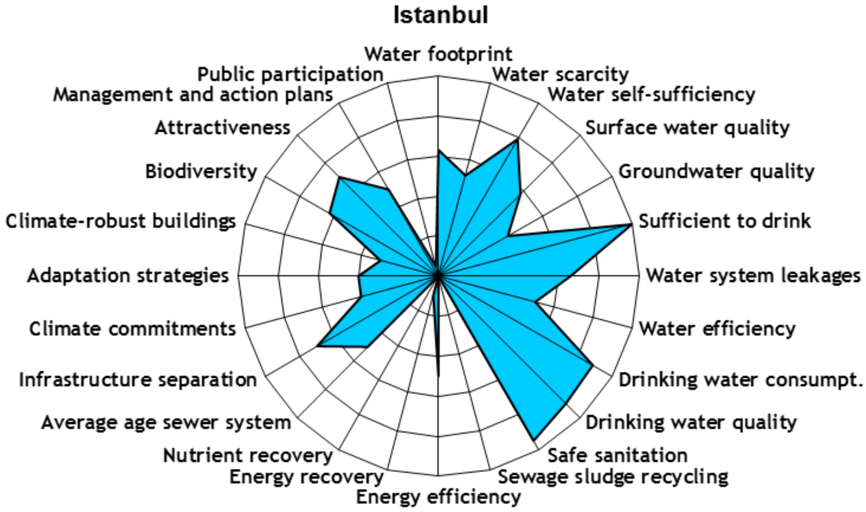


Figure 10. City Blueprints of 8 cities with increasing BCI values. Kilamba Kiaxi (BCI of 3.5), Dar Es Salaam (BCI of 4.3) Malta (BCI of 4.8), Istanbul (BCI of 5.2), Zaragoza (BCI of 6.6), Melbourne (BCI of 7.0), Amsterdam (BCI of 7.6), and Malmö (BCI of 8.0).





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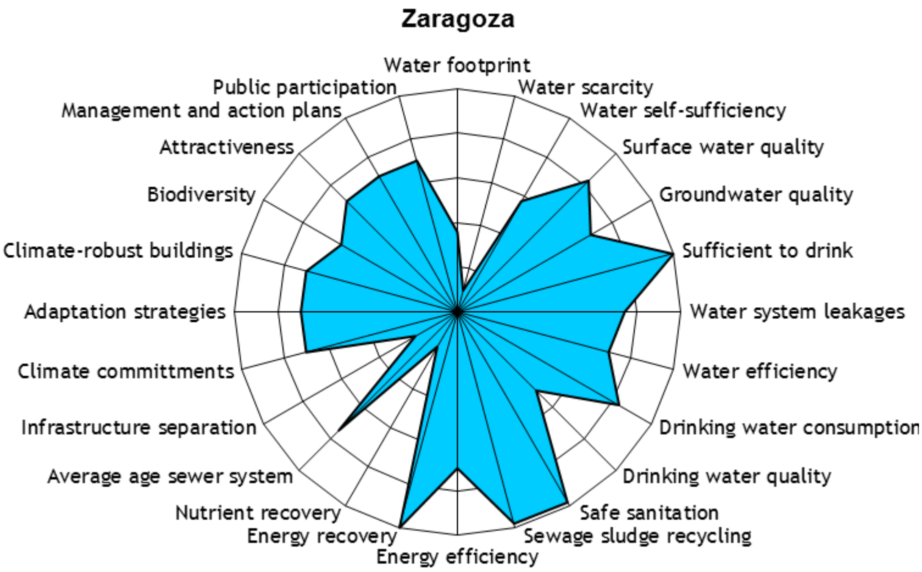

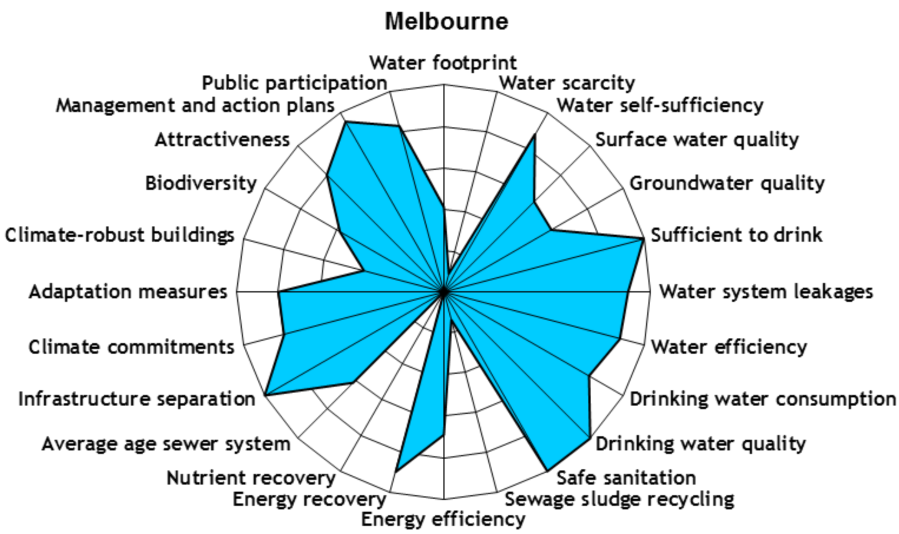

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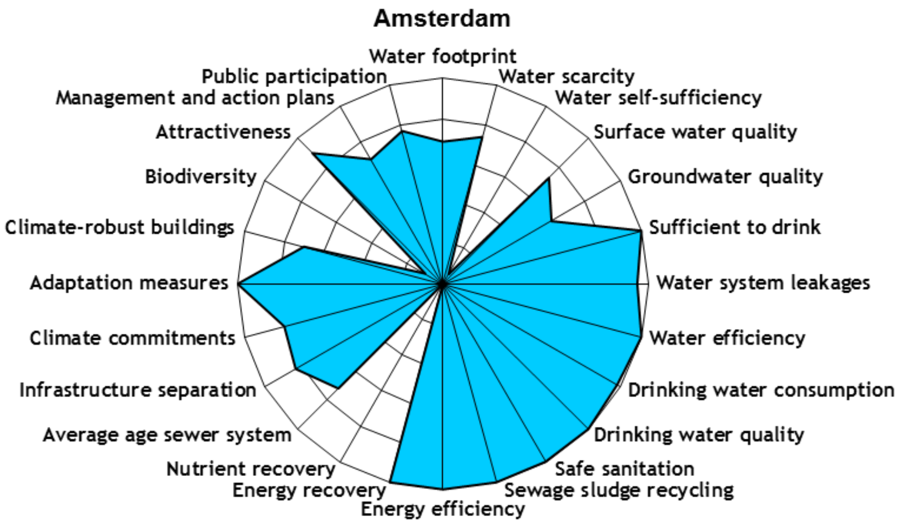

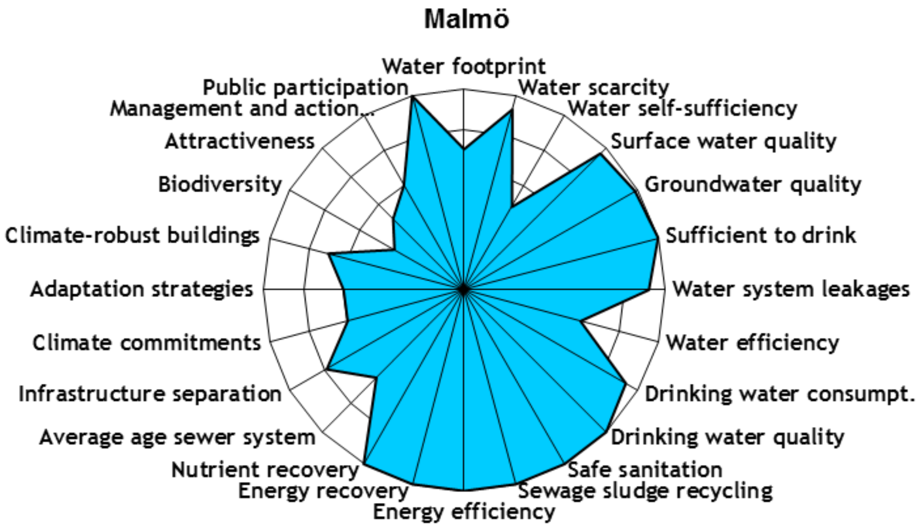

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Blue City Index (BCI)

The Blue City Index (BCI) is a simple indicator for the performance of the individual cities regarding the sustainability of their urban water systems. The BCI is the arithmetic mean of the 24 indicators comprising the city blueprint. These data are given in Table 3 below, together with some other indicators such as the scores for the commitments for UWCS (indicator 23), the VPI (voluntary participation index) according to the EFILWC (2006), and the GDP per capita (in international dollars for 2012 as reported by the International Monetary Fund (IMF, 2012). Comparisons were also made with some governance indicators according to the World Bank (2012) such as the GE (government effectiveness), RQ (regulatory quality) and RL (rule of law) as described by Kaufman *et al.* (2010). The RL is a national indicator capturing perceptions of the extent to which agents have confidence in and abide by rules of society, and in particular the quality of contract enforcement, property rights, the police, the courts, as well as the likelihood of crime and violence (Kaufman *et al.*, 2010).

Table 3. Summary information about the BCI, UWCS management and action plans (indicator 23) for the cities and various national indexes from the IMF and the World Bank. Abbreviations: see text.

City	BCI	UWCS	VPI	GDP	GE	RQ	V&A	RL
Algarve	5,8	1,0	6,0	23047	81,3	75,6	78,2	82,5
Amsterdam	7,6	7,7	7,0	41527	96,7	96,2	97,6	97,2
Ankara	6,0	0,5	5,0	14812	65,1	65,6	40,8	56,9
Athens	6,4	1,3	5,0	24260	62,2	68,4	67,3	63,5
Bucharest	5,2	0,7	6,0	12722	43,5	68,9	57,8	55,9
Dar es Salaam	4,3	0,3	2,0	1627	28,2	36,8	41,7	34,6
Genova	5,3	1,7	3,0	29812	66,0	74,6	73,9	62,1
Hamburg	8,0	3,3	10,0	38666	93,3	92,3	93,4	91,9
Ho Chi Minh City	5,4	0,3	7,0	3788	44,5	27,3	9,5	37,9
Istanbul	5,2	0,5	5,0	14812	65,1	65,6	40,8	56,9
Jerusalem	7,2	1,7	10,0	33878	86,1	85,2	65,9	77,7
Kilamba Kiaxi	3,5	0,2	2,0	6092	15,3	18,7	17,1	7,1
Lyon	7,2	3,0	7,0	35295	87,6	83,3	89,6	90,0
Maastricht	6,9	7,7	7,5	41527	96,7	96,2	97,6	97,2
Malmö	8,0	10,0	6,0	40304	98,6	99,0	99,5	99,1
Malta	4,8	2,3	4,0	26857	85,1	89,0	86,7	87,7
Manresa	6,6	1,7	6,0	30058	82,3	78,0	79,6	83,4
Melbourne	7,0	8,3	9,5	41954	94,3	97,1	96,2	94,8
Oslo	7,4	10,0	7,0	54397	98,1	71,9	100,0	100,0
Pisa	5,1	1,7	3,0	29812	66,0	74,6	73,9	62,1
Reggio Emilia	6,6	1,7	6,0	29812	66,0	74,6	73,9	62,1
Rotterdam	7,0	7,7	8,0	41527	96,7	96,2	97,6	97,2
Scotland	6,2	3,3	6,0	36569	91,9	94,7	92,4	92,9
Venlo	6,9	7,7	7,5	41527	96,7	96,2	97,6	97,2
Zaragoza	6,6	1,7	7,0	30058	82,3	78,0	79,6	83,4

Like in the European green city index (2009), there is a positive and significant relation between the performance of the cities/regions regarding their water services (BCI) and the VPI (Figure 11). The Pearson correlation coefficient (r) is 0.69. The BCI also correlates well with the UWCS commitments of the cities/regions (r = 0.80; Figure 12) and the GDP (r = 0,81; Figure 13). The BCI is also positively correlated with all governance indicators of the World Bank, for instance the government effectiveness (Figure 14). The correlation coefficient for the BCI and GE, RQ, VA and RL was 0.84, 0.74, 0.73 and 0,82, respectively. Further analysis of other World Bank Indicators has not been performed as in a previous study all World Bank indicators for the subset were strongly correlated (van Leeuwen, 2013). This is shown in Table 4, where also another World Bank indicator has been included, i.e. voice and accountability (VA).

Table 4. Pearson correlation matrix for the indicators for 25 cities in 18 different countries.

	BCI	VPI	UWCS	GDP-IMF	GE	RQ	VA	RL
BCI	X	0,69	0,80	0,81	0,84	0,74	0,73	0,82
VPI	0,69	X	0,47	0,83	0,74	0,65	0,75	0,75
UWCS	0,80	0,47	X	0,59	0,68	0,58	0,48	0,65
GDP	0,81	0,83	0,59	X	0,91	0,84	0,92	0,90
GE	0,84	0,74	0,68	0,91	X	0,92	0,89	0,98
RQ	0,74	0,65	0,58	0,84	0,92	X	0,92	0,93
VA	0,73	0,75	0,48	0,92	0,89	0,92	X	0,94
RL	0,82	0,75	0,65	0,90	0,98	0,93	0,94	X

VA captures perceptions of the extent to which a country's citizen are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media (Kaufman et al., 2010). These high correlations are demonstrated for e.g. RL and GE (0.98) and RL and RQ (0.93).

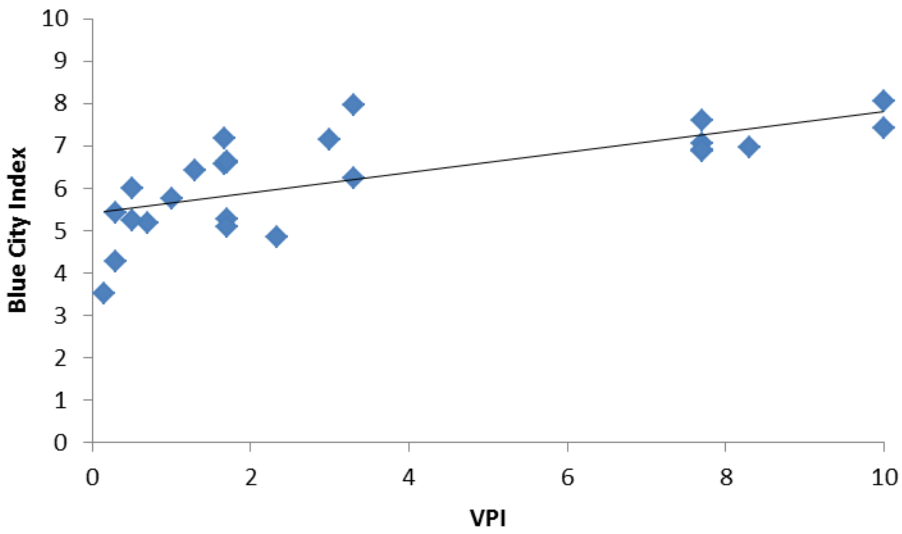

Figure 11. The relation between the BCI (blue city index) and Voluntary Participation Index (VPI).

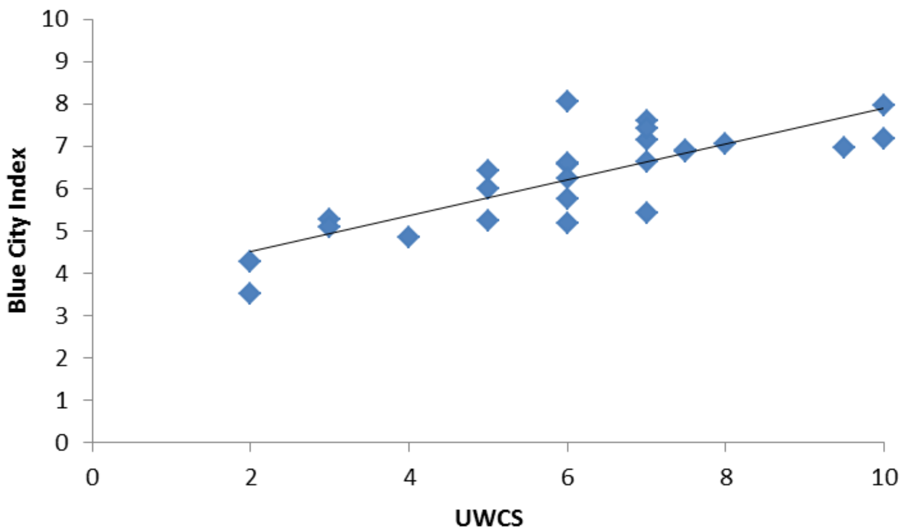

Figure 12. The relation between the BCI (blue city index) and UWCS commitments (indicator 23).

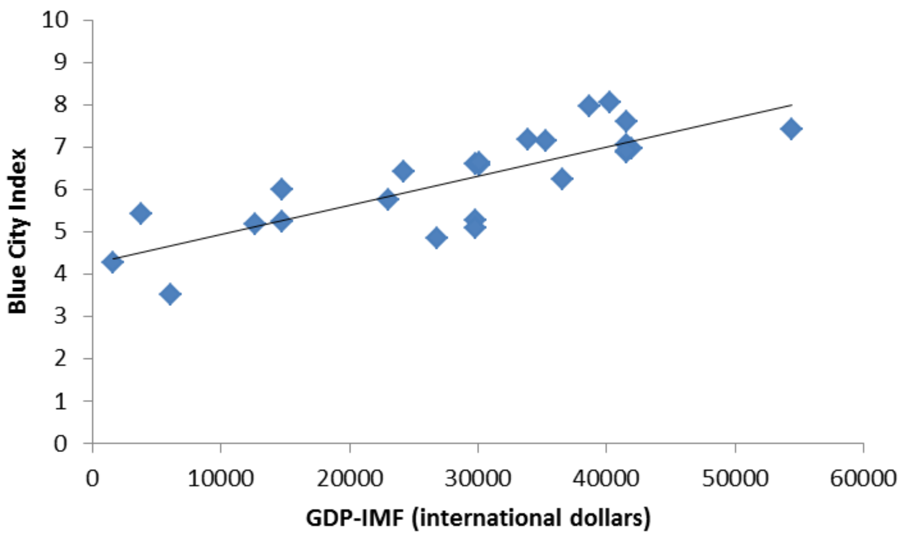

Figure 13. The relation between the BCI (blue city index) and the GDP per capita according to the IMF.

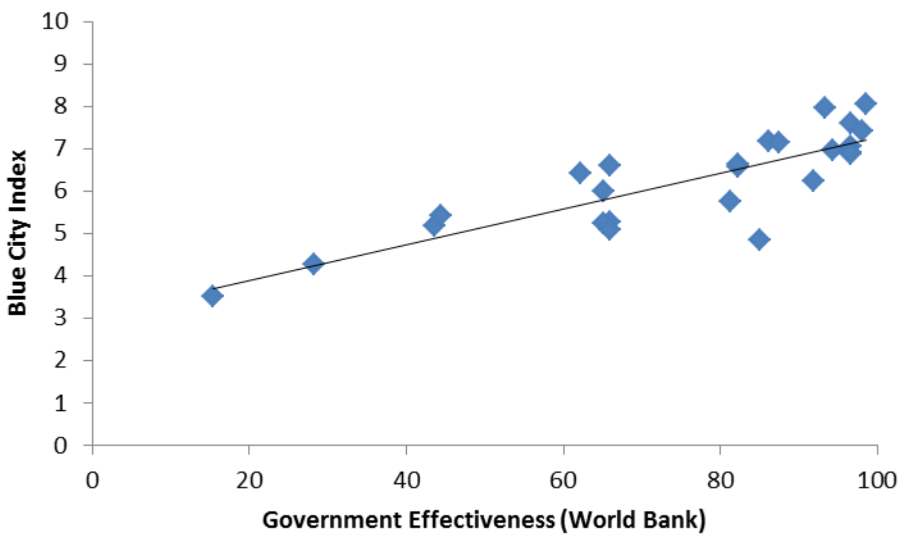

Figure 14. The relation between the BCI (blue city index) and government effectiveness.

Implementation of best practices

The global urban water challenges are high and the fastest route to failure in the transition towards sustainable cities would be to sit and wait for e.g. the ultimate technological breakthroughs in water technology. This is not at all necessary as many advanced technologies are currently available and implemented in many cities. The main challenge is to start the discussion with all stakeholders and to translate the baseline assessments into action. These actions may include further refined assessments on certain priority aspects of the UWCS based on this baseline assessment, or direct actions to improve the UWCS of cities in order to address the challenges ahead of us.

The most important result from this baseline assessment is that cities can learn from each other. This is shown in Table 5. In Table 5 the City Blueprint indicators are listed together with the best performing cities. In the third column the best score per indicator is given, to indicate what the current best practices are. In order to illustrate this further, a theoretical City Blueprint is provided in which all the best practices (best scores from Table 8) are given. This is shown in Figure 15. It should be noted directly that the implementation of “best practices” for some of these indicators – such as the water scarcity related indicators (1-3) is easier said than done, as these are based on national data and are determined by large-scale climatic, geological and hydrological processes. On the other hand, almost all indicators can be influenced directly at the level of the city, provided that other aspects are taken into consideration as well (Figure 16).

Table 5. Indicators, best performing cities and highest score per indicator for 25 cities.

Indicator		Lowest score	Best score	Best performing cities
1	Water footprint	3,4	8,4	DAR, HCM
2	Water scarcity	0,0	9,8	HCM, KIL, MLM, OSL
3	Water self-sufficiency	0,5	9,4	DAR, HCM
4	Surface water quality	2,4	9,6	DAR, LYO, MLM, OSL
5	Groundwater quality	1,4	9,8	MLM, OSL
6	Sufficient to drink	0,4	10,0	AMS, ANK, ATH, GEN, HAM, IST, JER, LYO, MAN, MEL, MLM, MLT, MST, OSL, ROT, VNL, ZAR
7	Water system leakages	5,0	9,6	AMS, HAM, MST, ROT, VNL
8	Water efficiency	2,0	10,0	AMS, JER, REG, ROT
9	Drinking water consumpt.	5,4	10,0	KIL, ROT
10	Drinking water quality	4,0	10,0	ALG, AMS, ATH, BUC, HAM, JER, LYO, MEL, MLM, MST, OSL, PIS, REG, SCO, VNL
11	Safe sanitation	0,0	10,0	AMS, MEL, MLM, MLT, OSL
12	Sewage sludge recycling	0,0	10,0	AMS, ATH,HAM,LYO, MAN, MLM, OSL, REG, ROT, VNL, MST
13	Energy efficiency	2,0	10,0	AMS, HAM, MLM
14	Energy recovery	0,0	10,0	AMS, ATH, HAM, MAN, MLM, ZAR
15	Nutrient recovery	0,0	10,0	HAM, MAN, MLM, REG
16	Average age sewer system	2,0	8,5	ALG, ATH,HCM
17	Infrastructure separation	0,0	10,0	ANK, JER, MEL
18	Climate commitments	2,0	10,0	HAM, JER, ROT
19	Adaptation strategies	2,0	10,0	AMS, HAM, JER, ROT
20	Climate-robust buildings	2,0	10,0	HAM, JER, ROT
21	Biodiversity	1,0	7,8	DAR, HCM
22	Attractiveness	1,0	10,0	AMS, ATH, HAM, JER, OSL
23	Management and action plans	2,0	10,0	HAM, JER, MEL
24	Public participation	0,2	10,0	MLM, MST, OSL, VNL

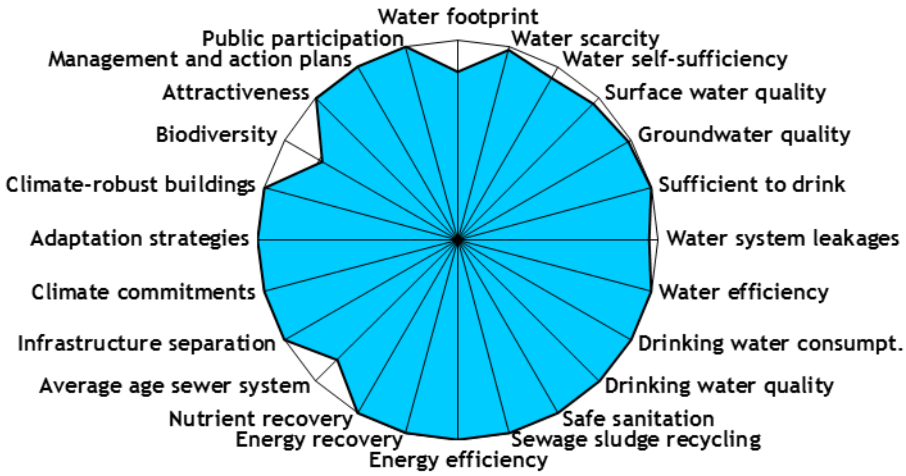

Figure 15. City Blueprint of a theoretical city that has implemented all the best practices (best scores as listed in Table 5) currently available in all cities presented in this report. It shows that cities can learn from each other and that active exchange of "best practices", can significantly improve the sustainability of UWCS of cities.

Discussion

Methodological aspects

The key characteristics of a good indicator are: (1) easy to access, (2) easy to understand, (3) timely and relevant, (4) reliable and consistent, (5) credible, transparent and accurate, and (6) developed with the end-user in mind (Norman *et al.*, 2010). The choice of indicators for the TRUST Questionnaire and the city blueprint (Annex 1) are per definition subjective. There are many options for other indicators and a variety of methods to quantify them. However, the selected questions and indicators provide for a good overview of the key sustainability issues in UWCS. The quality of input data has been a major issue. The baseline assessment of the TRUST cities has shown that the choice of the indicators is driven by the availability, quality and comparability of the input data. The survey responders have provided the most reliable data for the UWCS. In a couple of cases no local information could be provided, and assessments were based on regional or national information. In some cases there was no information at all and expert judgement scores or best professional "guesstimates" have been provided. For instance, the water security, environmental quality and VPI data have been obtained from regional or national data sources. Depending on the size of the country and the regional differences in e.g. precipitation, soil type, pollution and social aspects, the use of these regional/national data may lead to serious errors in the assessment of the local situation.

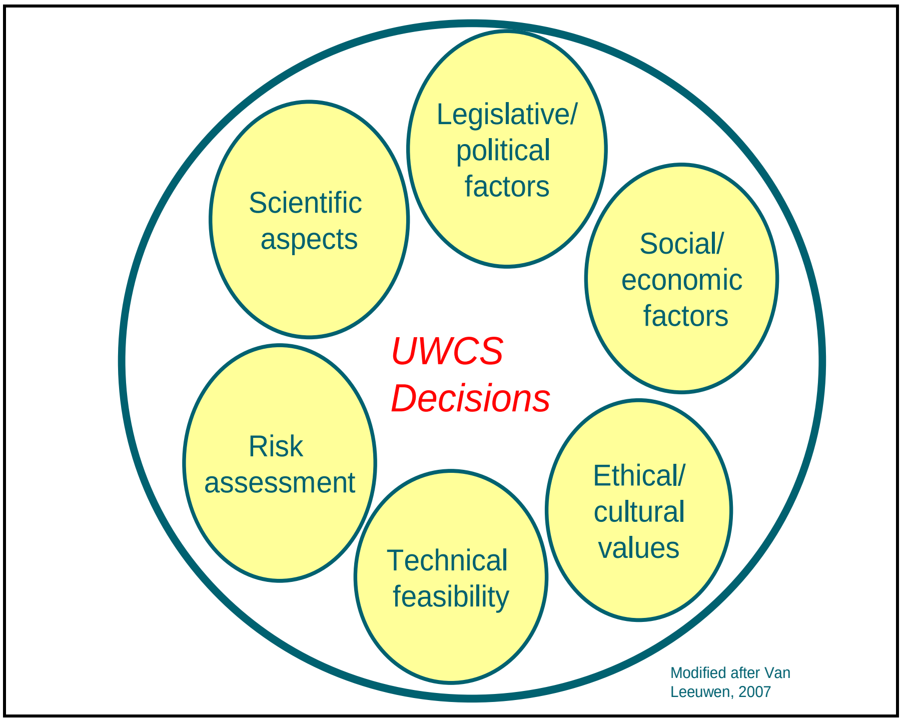

Figure 16. Elements of UWCS decision-making.

Retrospectively, it would have been better to modify the TRUST questionnaire (Annex 1). Certain questions could have been deleted whereas in other cases more refined information is needed. For instance, question 32 (climate change) can mean different things to different people. It may implicitly address related, but totally different issues such as: (1) concrete greenhouse gas reduction targets, (2) safety; i.e. adaptation strategies and measures against flooding, (3) safety; i.e. measures to combat water scarcity, (4) measures to increase green cover (park, trees and agricultural surfaces in urban areas) to reduce the "heat island" effects. Answers on this question have been used to score indicators 18 (climate commitments) and 19 (safety). Cities may put different priorities to these aspects.

We have followed a learning by doing approach. All cities have now been assessed in a similar manner and this may lead to minor changes compared to our previous publications. The assessments of the cities are dependent on data availability and data quality (Van Leeuwen, 2013). Unfortunately, no harmonized local data were available on water security, surface and groundwater quality, biodiversity and public participation. This has forced us in the direction of using regional or national information. The clear consequence of this is also that no absolute values should be attached to the environmental quality data. Most likely the cities are more polluted and show a greater lack of biodiversity than national/regional data would suggest. The use of national or regional information on environmental quality as used in this report may lead to serious overestimations of local environmental quality as cities are often sources of pollution. The use of local information rather than national data on e.g. water quality for a variety of cities leads to much lower scores. This is summarized in Table 6. Especially in those cities were waste water treatment is nearly absent, e.g. in Ho Chi Minh City and Dar es Salaam, severe surface water pollution can be observed.

Table 6. Difference between the score of indicator 4 (surface water quality) based on local information and information of the EPI water quality index score at a national level.

City	Local score	EPI Water Index
Amsterdam	6,0	7,3
Ankara	4,0	5,8
Athens	4,0	7,7
Dar es Salaam	4,0	8,5
Ho Chi Minh City	3,0	7,3
Istanbul	4,5	5,8
Melbourne	6,0	6,2
Maastricht	3,5	7,3
Rotterdam	4,0	7,3
Venlo	4,0	7,3

In other words the scores as provided in the current report on environmental quality are probably too optimistic and are real underestimations of the actual environmental quality of the cities. Furthermore, many water pollutants have not been accounted for. The 2010 EPI Water Quality Index uses only three parameters measuring nutrient levels (dissolved oxygen, total nitrogen, and total phosphorus) and two parameters measuring water chemistry (pH and conductivity). These parameters were selected because they cover issues of global relevance (eutrophication, nutrient pollution, acidification, and salinization) and because they are the most consistently reported. The consequence of this is that important groups of chemicals such as persistent organic pollutants (POPs), persistent bioaccumulating and toxic chemicals (PBTs), endocrine disrupters and many other groups of micropollutants have not been addressed at all. Again, this may lead to a serious underestimation of the actual pollution status in cities. Pollutants in many of Europe's surface waters have led to detrimental effects on aquatic ecosystems and the loss of aquatic flora and fauna. Clear downward trends in water quality determinants related to urban and industrial wastewater are evident in most of Europe's surface waters, although these trends have levelled in recent years (EEA, 2010). This is also reflected in the low scores for the biodiversity of surface waters in this report.

While water is generally abundant in much of Northern Europe, water scarcity and droughts continue to affect some areas. Water scarcity and droughts have direct impacts on citizens and economic sectors. Activities with high water demand, such as irrigated agriculture, tourism and the use of cooling water, are heavily affected by water scarcity. Over-abstraction is causing low river flows, lowered groundwater levels and the drying-up of wetlands, with detrimental impacts on freshwater ecosystems. In this report three approaches have been used to describe water scarcity. These aspects have been explained in Section 3.1. The approach from the Water Footprint Network is totally different from the traditional water statistics as provided by FAO. This is why we have also provided the FAO statistics and the data from WFN in the graphs of the city blueprints (indicators 1-3). The rise in demand for water to grow food, supply industries, and sustain urban and rural populations has led to a growing scarcity of freshwater in many parts of the world. This places considerable importance on the accuracy of indicators used to characterize and map water scarcity worldwide. The current indicators do not optimally address these complexities. (Hoekstra *et al.*, 2012; Hoekstra and Mekonnen, 2011). Further information on water scarcity for Europe is also provided by the WEI as presented in Figures 4 and 9. In the resolution adopted at the beginning of July 2012 by the European Parliament on the implementation of the EU water legislation, MEPs notably "recall that about 20 % of water in the EU is lost due to inefficiency, so that improving efficiency in the use of water resources is key to sustainable water management and, in particular, to dealing with the problems of water scarcity and drought; and emphasise the nexus between energy production, energy efficiency and water security". This is probably the reason why during the most recent European Green week the statement was made that "We have a water governance crisis rather than a water crisis".

Results and limitations of the assessment

The City Blueprint assessment is a quick scan and proposed as a first step of gaining a better understanding of UWCS and the challenges ahead. This has been accomplished. The inherent limitations are that the baseline assessment does not cover all aspects of the UWCS. Some aspects of UWCS are addressed very generally. The assessment is also snapshot. It is a picture and, therefore, does not address long-term trends in UWCS stress and adaptations. So the assessment is static and not dynamic. For instance in the discussion with the city of Oslo, we were informed about the need for Oslo to provide more drinking water in the very near future. Similar information was obtained from the city of Dar es Salaam in Tanzania where the population is expected to double in size in the next decade. This information has not been included in the calculations but has been provided as additional information in the short city reports as provided in Annex 3. Finally, care should be taken to attach absolute value to the results. The City Blueprint and the city reports in Annex 3 can be used as a preliminary decision support tool and information, but other aspects need to be included as well (Figure 16; Van Pelt and Swart, 2011). When these limitations are taken into account, the baseline assessment provides stakeholders in TRUST pilot cities and regions with a basic insight in the current status of the sustainability of their UWCS. It enables stakeholders to internally reflect upon the current status in terms of possible consequences for future UWCS management and to share the results with other colleagues, to discuss potential improvements. Most importantly, the assessments can be used to learn from each other's experiences. Although there are clear differences among the UWCS of the cities in this report, the most important conclusion from this study is that cities can learn from each other (Figure 13). The learning potential would theoretically allow an increase in the range of BCI scores from 3.5 (Kilamba Kiaxi) and 8.0 (Hamburg and Malmö) to 9.70 (Figure 15). We hope and expect that the results of this baseline survey of UWCS will be used to:

1. Refine parts of the assessment, with tailor-made in-depth studies and advanced models, if necessary
2. Identify priorities and budgets (planning)
3. Raise/improve awareness (particularly in communicating with the public) Translate knowledge and educate
4. Enable informed decision-making
5. Aid in the evaluation and approval (through decision-making) processes
6. Monitor and measure progress
7. Compare outcomes
8. Stimulate the exchange of best practices for UWCS (Makropoulos *et al.*, 2012; UNEP, 2008).

Measures

Hundreds of millions of people in urban areas across the world will be affected by climate change. The vulnerability of human settlements will increase through rising sea levels, inland floods, frequent and stronger tropical cyclones, and periods of increased heat and the spread of diseases. Climate change may worsen the access to basic urban services and the quality of life in cities. Most affected are the urban poor – the slum dwellers in developing countries (UN Habitat, 2010). This probably also holds for Europe, where climate change is projected to increase water shortages, particularly in the Mediterranean region. Many best practices in the context of UWCS have been summarized by Makropoulos *et al.* (2012). Specific measures related to water scarcity have been summarized by UNEP (2008), the EU TRUST project (http://www.trust-i.net/downloads/index.php?iddesc=66) and in a short presentation published on the EIP website of the City Blueprint Action Group (http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions), whereas water management options related to climate change have been presented by De Graaf et al. (2007a,b).

Conclusions

Smart cities are water wise cities. The baseline assessments of 25 cities presented in this report (see red box in Figure 15) showed that cities vary considerably with regard to the sustainability of the UWCS. We have tried to capture this in individual city reports (Annex 3 of this report) and in the Blue City Index (BCI), the arithmetic mean of 24 indicators comprising the City Blueprint (Van Leeuwen *et al.*, 2012; Van Leeuwen, 2013). The BCI varied from 3.5 (Kilamba Kiaxi) to 8.0 (Hamburg and Malmö).

Although correlation coefficients are no cause-effect relationships, cities with the best BCI are cities:

- With an active civil society expressed as VPI (r=0.69)
- With high UWCS commitments (r=0.80)
- In countries with a high GDP (r=0.81)
- In counties with a high governance effectiveness (r=0.84)

Ultimate technological breakthroughs in water technology are not the prerequisite for sustainable integrated water resources management. The main challenge is to start the discussion with all stakeholders, to enhance public participation, and to translate the baseline assessments into visioning, scenario building and strategy development (Figure 17) and, finally into actions to improve the UWCS of cities in order to address the challenges ahead of us (Figure 18).

The most important result from this study is that the variability in sustainability among the UWCS of the cities offers excellent opportunities for short-term and long-term improvements, provided that cities share their best practices as shown in Figure 15. Cities can learn from each other! Theoretically, if cities would share their best practices, the BCI might reach a value of 9.70, which is close to the theoretical maximum of 10. It shows that even cities that currently perform well, can still improve their UWCS. Of course, this would depend on many other factors, such as socio-economic and political considerations (Figure 16), and is ultimately the responsibility of the cities themselves.

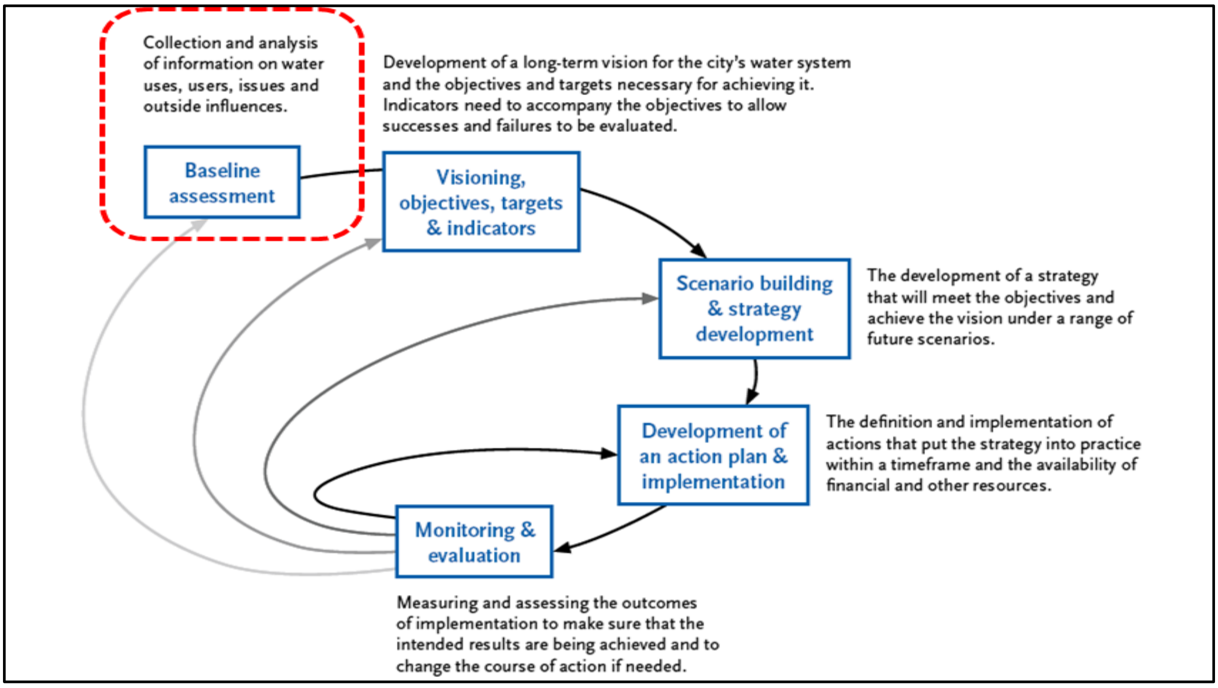

Figure 17. The City Blueprint is a baseline assessment and just the first step of a long-term process to improve the sustainability of the UWCS. Source: Philip et al., 2011.

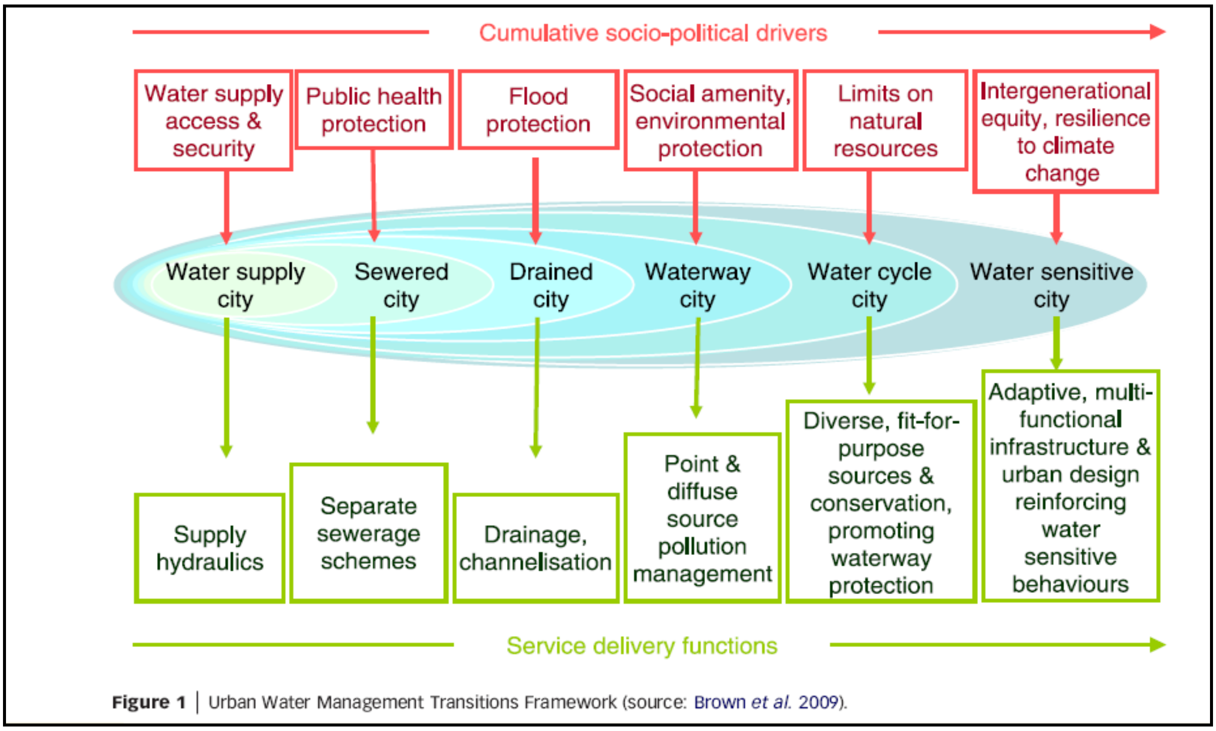

Figure 18. Transitions of UWCS in cities according to Brown et al. (2009).

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Annexes

Annex 1a. Indicators of the City Blueprint (Van Leeuwen *et al.*, 2012; Van Leeuwen and Chandy, 2012; Van Leeuwen, 2013)[a]

Indicator	Assessment criterion	Description
Water security		
1. Total water footprint (N)	En11	Total volume of freshwater that is used to produce the goods and services consumed by the community (Hoekstra and Chapagain, 2007; Hoekstra *et al.*, 2011;Mekonnen and Hoekstra, 2011)
2. Water scarcity (N)	En11	Ratio of total water footprint to total renewable water resources (Hoekstra and Chapagain, 2007; Hoekstra *et al.*, 2011; Mekonnen and Hoekstra, 2011)
3. Water self-sufficiency (N)	En11	Ratio of the internal to the total water footprint. Self-sufficiency is 100% if all the water needed is available and taken from within own territory (Hoekstra and Chapagain, 2007; Hoekstra *et al.*, 2011; Mekonnen and Hoekstra, 2011)
Water quality		
4. Surface water quality (N)	En21	Assessment of the water quality preferably based on international standards for e.g. microbial risks, nutrients, BOD and organic/inorganic micro-contaminants (European Commission, 2000)
5. Groundwater quality (N)	En21	Assessment of quality preferably based on international standards for e.g. microbial risks, nutrients, BOD and organic/inorganic micro-contaminants (European Commission, 2006)
Drinking water		
6. Sufficient to drink	S11	Percentage of city population, with potable water supply service (Global city indicators facility, 2008; Sustainable Society Foundation, 2010; UN, 2007)
7. Water system leakages	A12	Percentage of water lost in the distribution system (European green city index 2009)
8. Water efficiency	En11	Assessment of the comprehensiveness of measures to improve the efficiency of water usage (Jenerette and Larsen, 2006)
9. Consumption	S11	Domestic water consumption per capita (liters/day) (Global city indicators facility, 2008)
10. Quality	S22	Percentage of drinking water meeting the WHO water quality guidelines or the EU Drinking Water Directive (EBC, 2010; European Commission, 1998; Global city indicators facility,

		2008; Sustainable Society Foundation, 2010)
Sanitation		
11. Safe sanitation	S22	Percentage of city population served by wastewater collection and treatment (European green city index, 2009; Global city indicators facility, 2008; Sustainable Society Foundation 2010; UN, 2007)
12. Recycling of sewage sludge	En21	Percentage of total sewage sludge that is thermally processed and/or applied in agriculture.
13. Energy efficiency	En12	Assessment of the comprehensiveness of measures to improve the efficiency of wastewater treatment (European green city, index 2009; UN, 2007)
14. Energy recovery	En12	Percentage of wastewater treated with techniques to generate and recover energy (Daigger, 2009; Frijns *et al.*, 2009; Verstraete *et al.*, 2009;)
15. Nutrient recovery	En21	Percentage of wastewater treated with techniques to recover nutrients, especially phosphate (Cohen, 2007; Daigger, 2009; Frijns *et al.*, 2009; Verstraete *et al.*, 2009)
Infrastructure		
16. Average age	A11	Average age of infrastructure for wastewater collection and distribution
17. Separation of wastewater and stormwater	A13	Percentage of separation of the infrastructures for wastewater and storm water collection (EBC, 2010; Sustainable Society Foundation, 2010; Tredoux *et al.*, 1999; UN, 2007)
Climate robustness		
18. Commitments to climate change	A14	Assessment of how ambitious and comprehensive strategies and actual commitments are on climate change (Australian Conservation Foundation, 2010; European green city index, 2009; Forum for the future, 2010; Global city indicators facility, 2008)
19. Climate change adaptation measures	A14	Assessment of measures taken to protect citizens against flooding and water scarcity, including sustainable drainage (Deltares, 2009; EEA, 2012; Nederlof *et al.*, 2010)
20. Climate-robust buildings	A14	Assessment of energy efficiency for heating and cooling, including geothermal energy (Charlesworth, 2010)
Biodiversity and attractiveness		
21. Biodiversity (R)	En21	Biodiversity of aquatic ecosystems according to the WFD (European Commission, 2000)
22. Attractiveness	S21	Water supporting the quality of the urban landscape as measured by community sentiment within the city (Costanza

		et al., 1997; European green city index, 2009)
Governance		
23. Management and action plans	G31	Measure of local and regional commitments to adaptive, multifunctional, infrastructure and design for UWCS as demonstrated by the ambition of the action plans and actual commitments (Brown and Farrelly, 2009; European green city index, 2009; Fleming, 2008;)
24. Public participation (N)	G11	Proportion of individuals who volunteer for a group or organization as a measure of local community strength and the willingness of residents to engage in activities for which they are not remunerated. Public participation is an indicator of stakeholder equity in the planning process (Brown, 2009; Brown and Farrelly, 2009; EFILWC, 2006; European green city index, 2009)

[a] All indicators are at the level of the city or region. If this information was not available regional (R) or national (N) data were used.