CE100

COLLABORATIVE PROJECT

WATER AND CIRCULAR ECONOMY

WHITE PAPER

ARUP anteagroup ELLEN MACARTHUR FOUNDATION

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Right: Anaerobic Digesters, Cardiff WWTW

INTRODUCTION

Water systems intersect with all sections of society and industry. Opportunities exist in these interfaces to create additional value by application of circular economy principles.

This white paper sets out the theoretical basis for a framework to identify the opportunities that are offered through applying circular economy principles to water systems and through incorporating sustainable water management principles in the circular initiatives in other sectors.

The paper explores the relationship between the principles of circular economy and Sustainable Water Management, establishing a common language to enable effective communication between circular economy and Water Management practitioners.

These presented concepts have been peer reviewed and accepted by a working group of professionals from industry, academia and water utilities.

> *"Do unto those downstream as you would have those upstream do unto you."*
>
> *- Wendell Berry*

Above: The Crystal Building, London

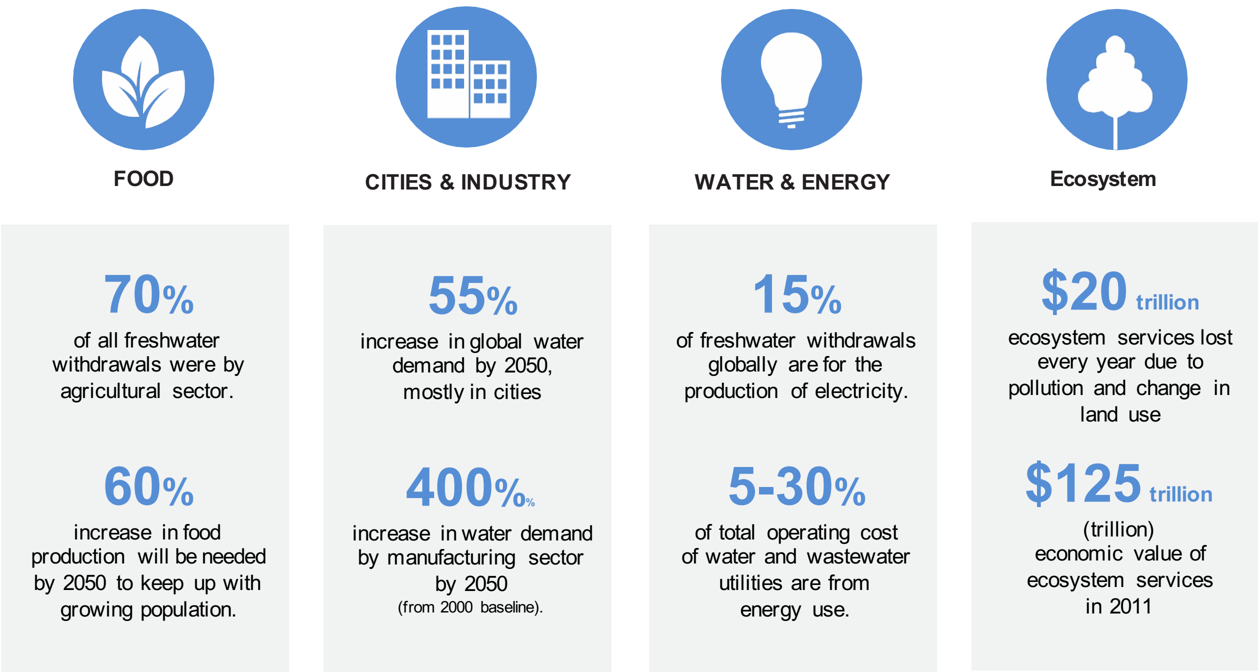


Figure 1: Facts and figures about global water systems

Understanding the governance across the Water Cycle is important if we are going to maximise the value of circular economy thinking. This approach can help us address the key challenges that the world's water system face, such as:

- Global demand for freshwater will exceed viable resources by 40% by 2030, if we continue with business as usual.
- Agriculture is the largest user of water followed by industry, with detriment to water availability and water quality.
- The demand for water in manufacturing is expected to increase 400% by 2050
- Climate change and increase in pollutants will further deplete the quality and amount of available freshwater resources

There is enough water to meet the world's growing needs, but the statistics and projections highlight that it will not be achievable without dramatically changing the way water is used, managed and shared.

System level change including the use of new enterprise models, will be necessary to maximize the extraction of value from water cycles at all scales (river basin, city, industrial unit, building) increase effectiveness in the use of water resources and prevent further degradation of the environment.

Adopting a circular economy approach, based on the three principles of circular economy, presents a tremendous opportunity for businesses, governments and cities to minimise structural waste and thus realise greater value from industry and agriculture while regenerating the environment.

A circular economy is inspired by natural systems, so its foundation lies in system-thinking. Renewable resources should be used wherever possible, natural systems are preserved or enhanced; waste and negative impacts are designed out. Materials, water, products and components are managed in loops, maintaining them at their highest possible intrinsic value.

Application of circular economy principles will require mapping the interactions of the water cycle, how it is used, and where within the river basin and urban water cycles value can be extracted and new enterprises established.

There is increasing momentum in both the transition towards a circular economy and in addressing the worsening impacts of the global water crisis. We see an opportunity to combine efforts to achieve mutual benefit. By establishing a common understanding amongst governments, industries and others who seek a desire for change, we believe there are ways to integrate aspects of two initiatives, reduce the distance in between and reach the goals they both seek to achieve.

This project, a collaboration between Arup, Antea Group and the Ellen MacArthur Foundation *Water & circular economy*, aims to kick start the integration. The project is split into two phases.

Phase 1 develops the common understanding between the water experts and circular economy experts, establishing a basis for a framework, and is outlined in this White Paper.

Phase 2 will collate wide ranging case studies that exemplify both water management and circular economy principles. These will be utilised to develop the scope of the framework that has been highlighted as of high interest by the CE100 Water & circular economy Working Group.

PHASE 1
CONCEPTUALISATION

The aim of Phase 1 was to look at circular economy principles through a lens of water systems, establish a common understanding for the two practitioner groups, and to develop an initial basis for a framework.

Our first step was to envisage how the circular economy relates to sustainable water management. This allowed us to draw out common understanding, develop key insights around dimensions of water use, and to identify where the opportunities lie for taking the first steps towards implementing a circular economy initiative that integrates with water management.

Above: Bosco Vrticale, Milan

1
THROUGH A WATER LENS

We first set out to describe how the circular economy principles relate to water systems and long established guiding principles of sustainable water management.

We looked at circular economy principles and considered how they could be achieved in a water system.

This created a foundation for establishing a common understanding.

2
ESTABLISH A COMMON UNDERSTANDING

Although many concepts regarding water stewardship are not new, there is a growing interest in understanding how the circular economy and water security issues overlap, and how the collective expertise from each of these disciplines can support each other.

We have a 'Perspectives' approach as a means to establish a common understanding between the circular economy and Water Cycle Experts.

We also utilised some industrial projects as examples to highlight the application of circular economy measures, as well as unrealised opportunities when water is taken into consideration. A similar approach was applied to water system projects to highlight unrealised circular economy potential.

3
STAKEHOLDER ENGAGEMENT

We engaged with CE100 members at Phoenix, Reykjavik and Kireckenbeck and other key representatives from the industry.

Engagement covered CE100 representatives from water and wastewater utilities, Food & Beverage Companies, Digital and Technology Companies, Academia, Government Agencies,

We also undertook a number of interviews with stakeholders of particular interest from outside of the CE100 network.

The discussions were focused on the Common Understanding, the various concepts that can be used as basis for a 'Water and circular economy' Framework.

4
NEXT STAGE

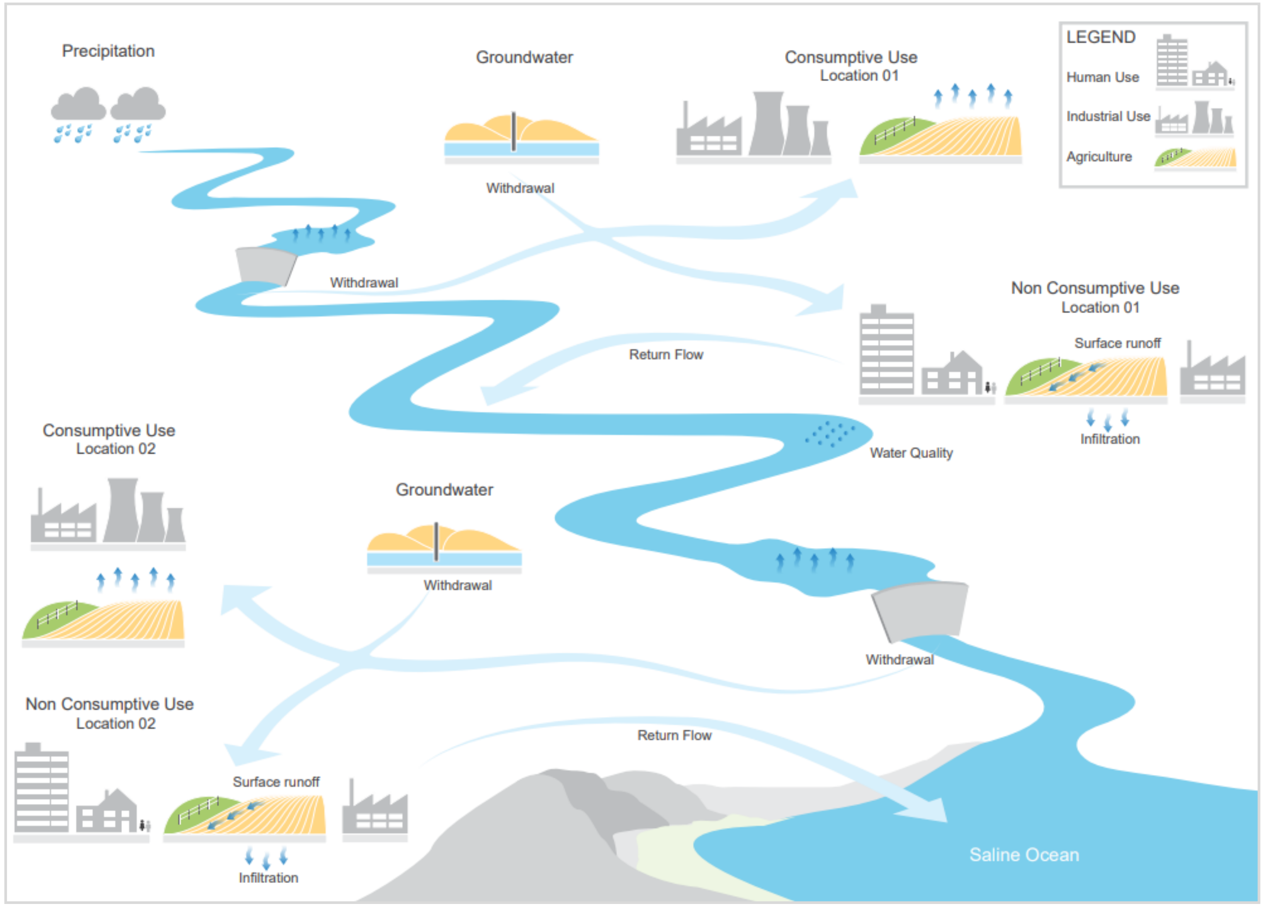
Through discussions within the project team and the CE100 Collaborative Project Working Group we have outlined potential next stages for the project.

The next stage ideas include establishing the knowledge base, enhancing ability to identify opportunities, developing tools to better evaluate the scale of the potential, as well as establishing the ability of the organisation to realise the benefits of transformative change that can be realised through the application of circular economy principles to their operations.

THROUGH A WATER LENS

CIRCULAR ECONOMY PRINCIPLES

Circular economy Principles	Application to Water Systems
1 DESIGN OUT WASTE & EXTERNALITIES	• Optimise the amount of energy, minerals, and chemicals used in operation of water systems in concert with other systems. • Optimise consumptive use of water within sub-basin in relation to adjacent sub-basins (e.g. use in agriculture or evaporative cooling) • Use measures or solutions which deliver the same outcome without using water
2 KEEP RESOURCES IN USE	• Optimise resource yields (water use & reuse, energy, minerals and chemicals) within water systems. • Optimise energy or resource extraction from the water system and maximise their reuse. • Optimise value generated in the interfaces of water system with other systems..
3 REGENERATE NATURAL SYSTEMS	• Maximise environmental flows by reducing consumptive and non-consumptive uses of water. • Preserve and enhance the natural capital (e.g. river restoration, pollution prevention, quality of effluent, etc.) • Ensure minimum disruption to natural water systems from human interactions and use.



Above: Water flows in a basin © Arup

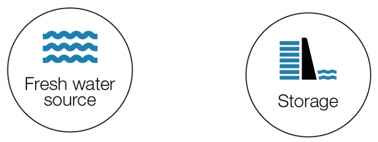
THROUGH A WATER LENS

LINEARITY OF CURRENT WATER SYSTEMS

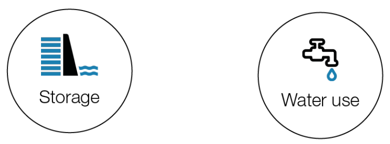
Systems thinking and environmental stewardship are core concepts to circular economy and for the management and supply of water. The interplay and relationship between these aspects is therefore important to considering any circular economy related initiatives.

In an effort to help those focused on transitioning to a circular economy to develop solutions with water systems experts, a common understanding of key concepts must be understood. To set the basis for this, this White Paper presents a circular economy diagram for the management and supply of water based on the principle of 'regenerative by design'.

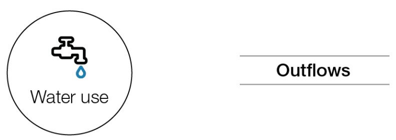
Similar to other materials, water is traditionally managed in a linear fashion. The Take-Make-Dispose approach that is characteristic of the material economy consumption is mirrored by Take-Use-Discharge, commonly adopted in the water sector.



Water is sourced, or 'withdrawn', from streams, rivers, lakes, reservoirs, oceans, and groundwater aquifers or harvested directly as rainwater.



Water is 'used' by four traditional categories: Agriculture, Municipality, Industries, Environment within the water cycle. This includes consumptive and non-consumptive uses.



Non consumptive used water is 'returned' to the basin directly or via a municipal treatment facility. Depending on location within the basin this returned water can then be further used downstream or lost to the basin in a similar way as consumptive uses.

This linear approach of human-managed water use, which is prevalent in a majority of basins today, is short-sighted and inherently unsustainable. The Take-Use-Discharge approach also goes against the principles of the circular economy.

To manage water systems for long-term sustainability, addressing the projected global and local demands for water, a circular approach is relevant, timely and achievable; at the same time offering opportunities for commercial advantage.

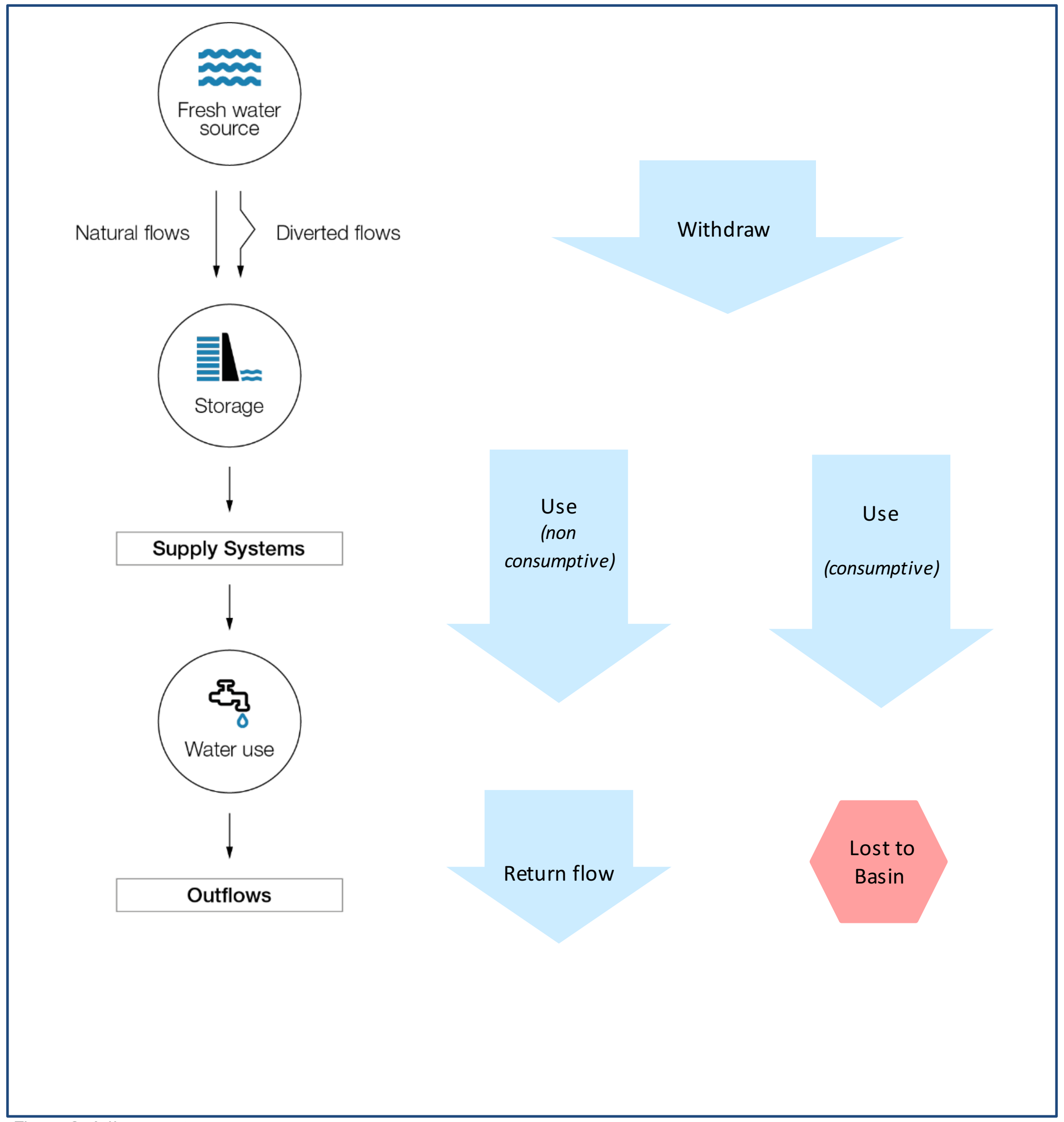


Figure 2: A linear water system

PERSPECTIVES

SETTING THE FOUNDATION FOR A FUTURE FRAMEWORK

A 'Dimensions of Use' Perspective

Water is fundamental to meeting basic needs of all living things. This service to life (including human consumption) cannot be satisfied by substituting water with other measures or materials.

Beyond this water is used and offers value in a number of different ways. The dimensions of water use can be clustered into the three themes of Service, Energy and Carrier (see diagram).

The three dimensions exist throughout the water cycle and are intrinsic in the Water Specific circular economy Systems Diagram.

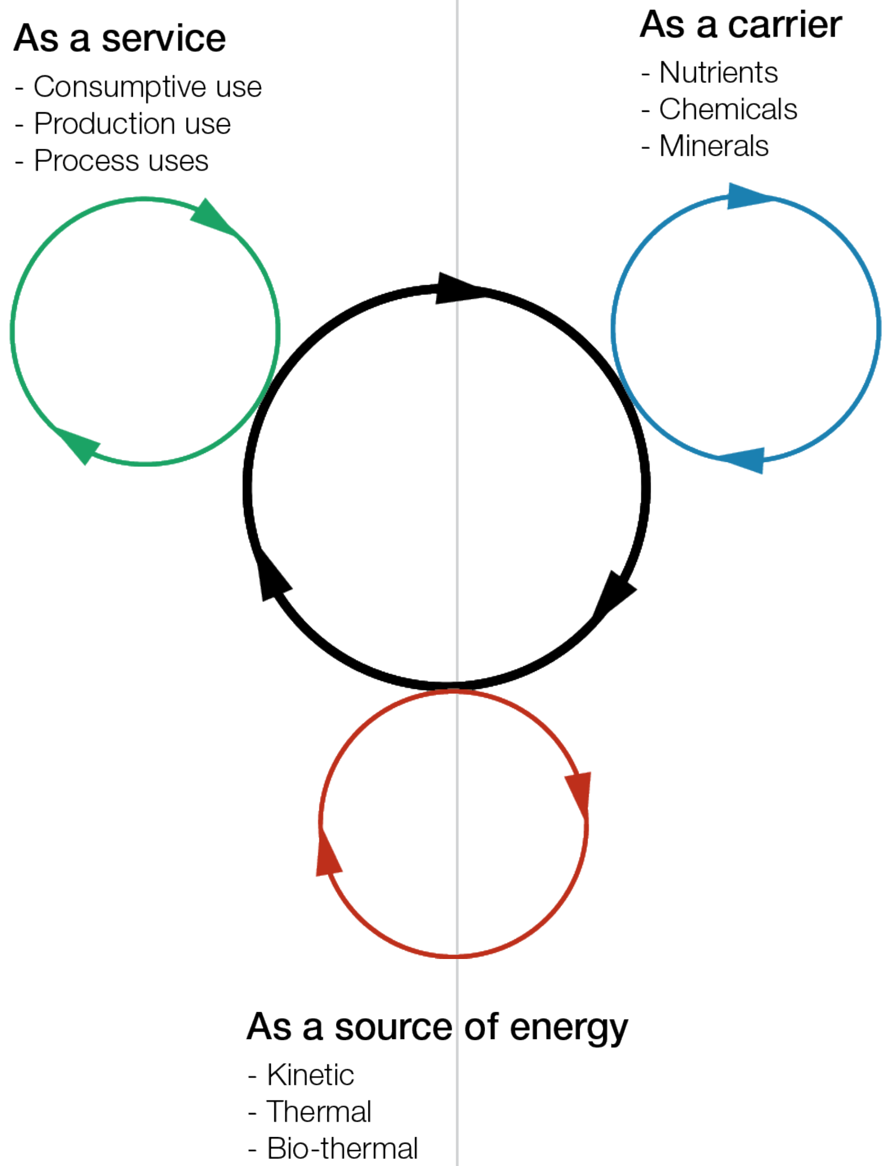
The dimensions of water also map against the Food – Water – Energy Nexus, e.g. nutrients (service), reducing consumptive uses (service), and generating energy (hydropower / biomass).

Whether these can be harnessed, optimized, value generated and appropriately balanced between nature and human needs will vary from basis to basin, societal development level, and the use category (agricultural, municipal, industrial or environmental)

Water as a service

Water provides services such as: sanitation in our homes and businesses, for cooling and heating our buildings, and as part of production processes in our factories. Water is often not fundamental to the service and the delivery of these outcomes can, at least in principle, be achieved by other means.

For example, water is ubiquitously used in evaporative cooling, but air forced cooling and can achieve the same service outcomes but at lower energy efficiencies.



Above: Dimensions of water diagram

Water as source of Energy

Water, through its physical properties and how it can be utilized can act as a source of energy.

- The mass and momentum in the flow of water can be harnessed to generate hydro-electric energy.
- The thermal properties enable it to absorb thermal energy from the environment or human activity that can be extracted (e.g. water source heat pumps and energy harvesting from sewers).
- Bio-thermal energy such as anaerobic digestion from municipal sewage.

Water as a Carrier

As a liquid natural resource, water is a commonly available and universal carrier in the natural and built environment. In both contexts water is acting as a carrier of chemicals, particles and droplets (dissolved and suspended state) which represent potential resource or pollutant.

In agricultural settings, there is high potential of nitrogen and phosphorus from fertilizers to be present.

Within municipal and industrial settings, it could include trace chemicals in treated water and wastewater.

Removal of these chemical and nutrients may be driven by economic reasons, but in many situations it is driven (by regulatory requirements), for pollution prevention and environmental protection, e.g. recent limits on nitrate and phosphate being implemented in the European Union.

Extracting nitrogen and phosphorus from final effluents at wastewater treatment plants before discharge provides potential benefits:

- Improves the quality of outflows to increase opportunity for water reuse and reduce cost of treatment for downstream users (e.g. for potable water treatment).
- Reduces environmental impacts and enhances natural capital;
- Offer the opportunity for use as fertilisers and enhance the Urban Bioloop potential.

PERSPECTIVES

SETTING THE FOUNDATION FOR A FUTURE FRAMEWORK

A 'Systems' Perspective

Although visually similar to the materials Systems Diagram, the water butterfly is instead divided into "nature managed" and "human managed" cycles.

Water is a complex system, so to simplify the applicability, the model currently represents a single basin. On the left side, water is depicted in its natural state where no human induced uses are occurring. There is continuous movement of water on, above and below the surface of the Earth.

Precipitation is naturally collected within the boundaries of a basin or basin flowing from higher to lower elevations and from source to sink, usually an ocean. Water is captured and held by soil, vegetation, and surface water bodies, ultimately percolating into the ground and aquifers.

Water also leaves a basin through evaporation and transpiration, engineered water flows, discharges to oceans, embedded in products or otherwise shipped out of the basin. The total volume of water available at a given time in a basin is called the watershed balance.

Nature Managed System

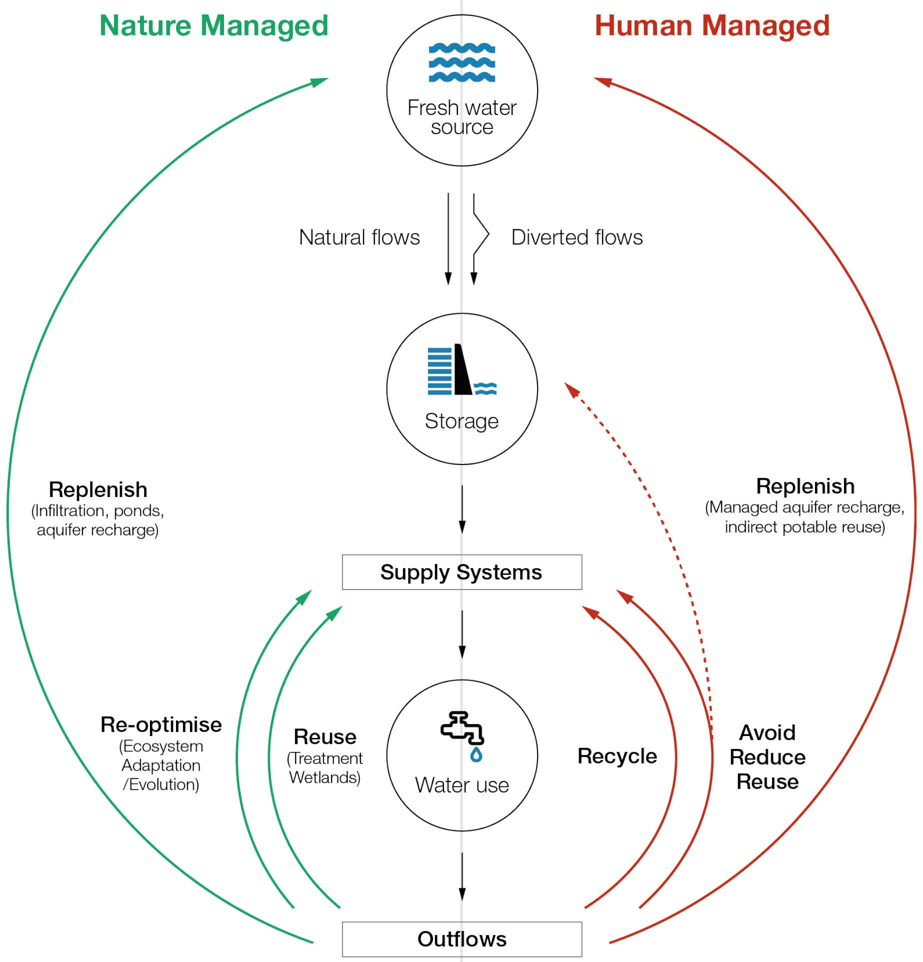
Within a **given basin, the natural water cycle** acts to re-optimise, reuse, and replenish water:

Re-optimise – nature needs a specific supply of water to maintain the ecosystem and biodiversity. This is naturally variable and based upon the complexity of the ecosystem, climate, and general ability to adapt by plants and animals to a changing environment.

Reuse – as water cycles it is naturally treated as it moves from higher to lower elevations and interacts with flora and fauna.

Replenish – the natural cycle concludes with a return of water to the environment through evapotranspiration, infiltration or surface water flows.

Right: Venlo City Hall



Human Managed System

On the Human Managed side, water's circularity is impacted by human action when we alter the natural water cycle, such as by:

- Abstracting freshwater above its rate of replenishment.
- Accelerating water loss through inefficient irrigation and distribution methods.
- Polluting water and limiting its utility for other users.

Such outcomes have adverse impact on the natural water cycle, and can result in economic and environmental losses or additional costs to meet the human needs.

The Opportunity

The opportunity with circular economy for Water is to better align the human water cycle with the natural water cycle through following measures:

Avoid Use – through rethinking products and services and eliminating ineffective actions.

Reduce Use – driving continuous improvements through water use efficiency and better resource allocation and management.

Reuse – pursuing any and all opportunities to reuse water within an operation (closed loop) and for external applications within the surrounding vicinity or community.

Recycle – within internal operations and / or for external applications.

Replenish – efficiently and effectively returning water to the basin.

The function of water use in these loops can have multiple dimensions. Understanding these is fundamental to realizing the opportunity and enterprise potential of water and circular economy.

PERSPECTIVES

SETTING THE FOUNDATION FOR A FUTURE FRAMEWORK

A 'Basin' Perspective

System of System

When viewed from a systems approach, water is a sub-system of a 'System of Systems', which includes the environment, agriculture, industry and municipal systems.

Application of systems thinking is critical for identification of the circular economy opportunities that exist within the water system as well as other associated systems.

A systems approach will also allow assessment of impacts and maximise value created as result of application of circular economy principles..

Variance due to basin typologies

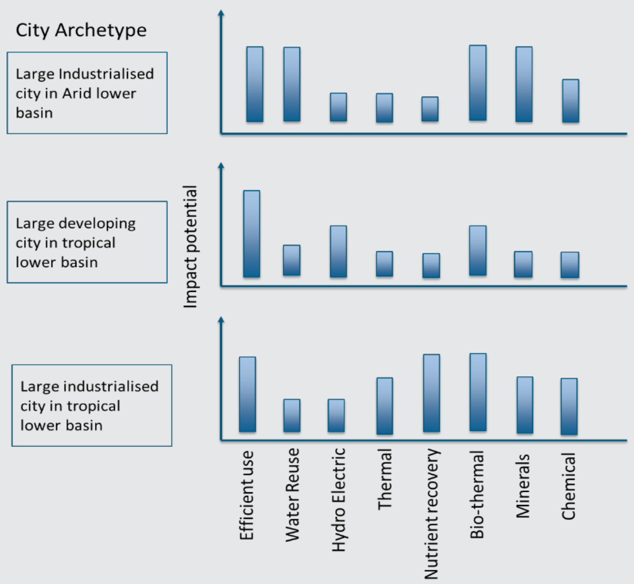
The type of basin has a significant bearing on the type of systems that are likely to be present, and the nature of the opportunities that would be present for generating additional value by application of circular economy principles.

Basin archetype characteristics include

- Climatic conditions
- City scale and development level,
- Use type: Environmental, Municipal, Industrial, Agriculture
- Topography and geography of basin, and
- Level of development in the city.

Variance due to city archetypes

The suite of solutions that have a high viability in one city archetype would have lower viability in another.



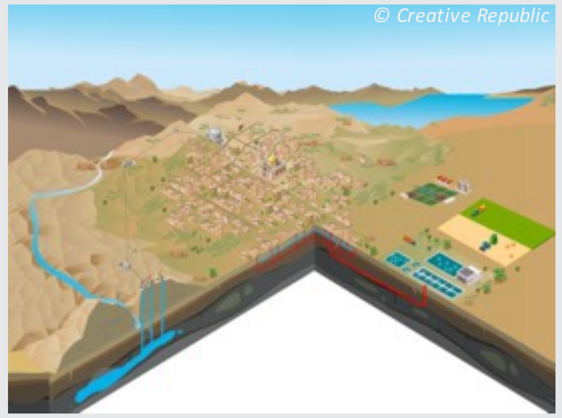
The suite of solutions that can be utilized would differ for each combination of city and basin archetype, and it is assumed that the value proposition of each of the solutions would also be different in the different contexts.

These perspectives are illustrated in the chart above and basic archetype graphics to the right.

To address the current knowledge gap on the solutions and value propositions, they would need to be researched as part of any future project.

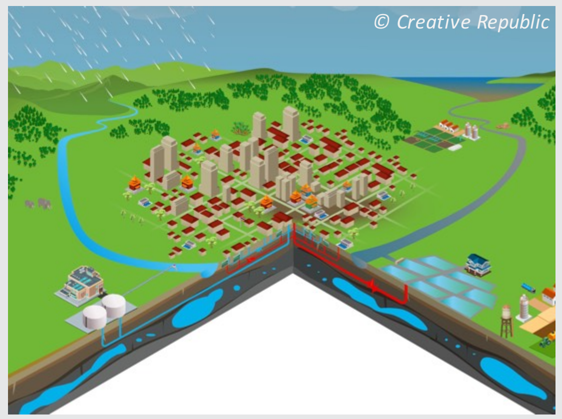
Arid lower plains

- Ecosystem services potentially high value
- Water reuse would be key measure
- Solutions that displace water with other measures would be suitable.



Lush green middle plains

- Water as service is key water use dimension.
- Low benefit for water reuse
- High value of water treatment to maximise utility for downstream users. Potential to extract nutrients



Upper Highlands

- Energy extraction a key water use dimension
- Water treatment of high value to maximise utility for downstream users.

PERSPECTIVES

SETTING THE FOUNDATION FOR A FUTURE FRAMEWORK

An 'Urban Water System' Perspective

Current projections indicate that world population will increase to 9.1 billion in 2050, with 60% living in cities or towns. As city populations expand, the design and operation of more effective urban water systems could be an avenue for achieving greater circularity within other city systems.

The figure to the right presents a simplified view of the components of a municipal water system, which in reality are more complex with greater level of links and interfaces with other systems.

A few potential circular economy initiatives identified on the image highlight how municipal water system interface with industry, energy systems, agriculture, food production, and the wider environment.

Energy: Water is key component in production of energy from hydropower and thermal power plants (gas, diesel, nuclear). Globally 15% of the freshwater withdrawals are for production of energy. In addition, energy accounts for up to 30% of the costs of operating a water and wastewater system.

Opportunities exist to reduce energy use by being more efficient in water use, as well as using the sludge from wastewater treatment to generate renewable energy.

Water Use: With an ever growing urban population, water demands from the cities and the impact of freshwater withdrawal on the environment will continue to increase.

Greater efficiency and water reuse can reduce the volume of freshwater withdrawn, reduce the energy required, and leave more water for the environment.

Food: The environmental footprint of a city extends way beyond the city limits or events its water basin. By growing food locally, as outlined in the Urban Bio-cycles scoping paper, the extent of the footprint can be reduced.

This will require extensive amounts of water, but solutions such as vertical farms in urban greenhouses can be more efficient in use of the water per kilogram of food produced in comparison to open fields.

The reduction in demand of open agriculture will reduce the freshwater withdrawals for agriculture, which have been estimated at 70% of all freshwater withdrawal.

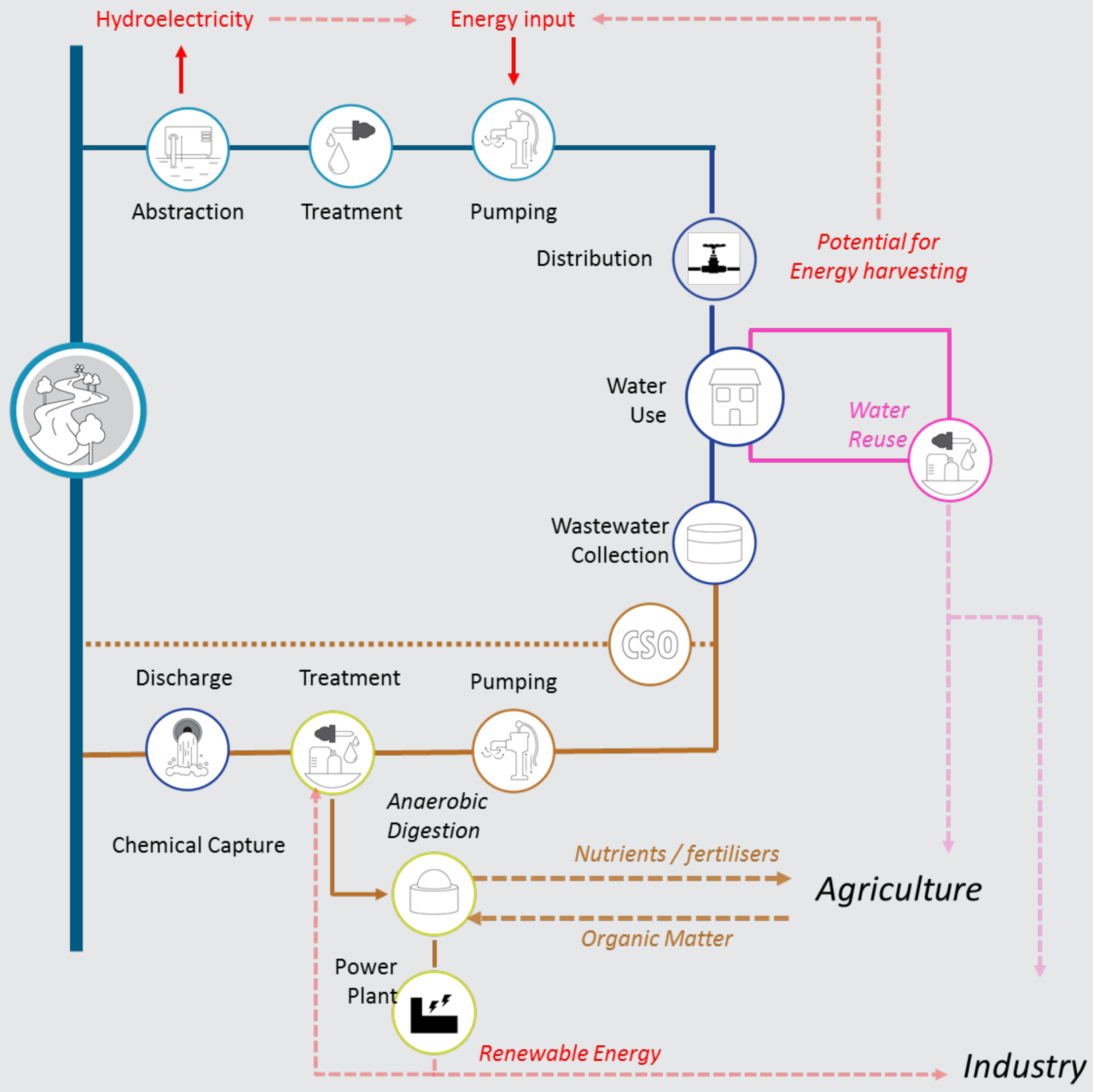
Urban Biocycle can also utilise the nutrients that are found in municipal effluents, reducing the amount of fertiliser production, as well as reducing the level of nutrients being discharged into the environment.

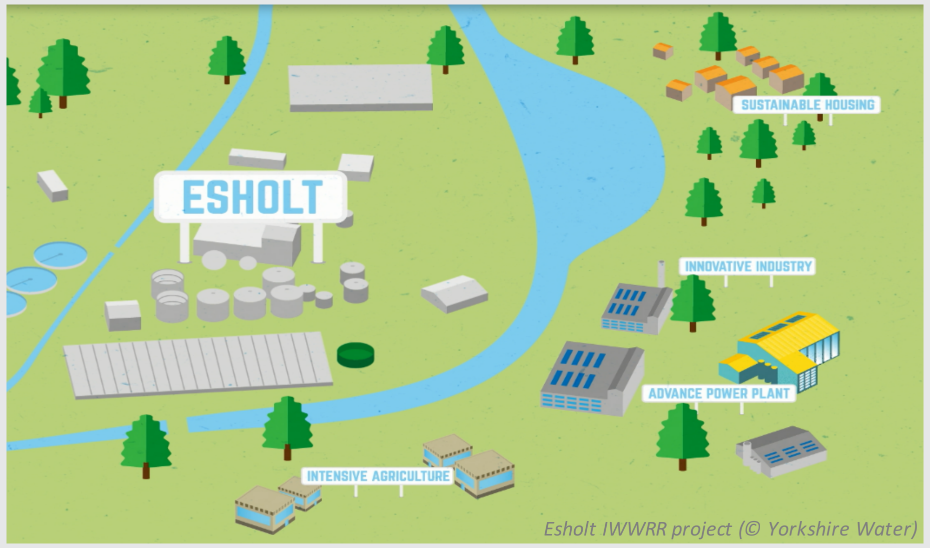
Industry: Industry is at a critical nexus of the water and energy. Most industrial processes utilise water, which can be as a component of the final product, a part of the production process, or even indirectly, through energy use.

Circular economy measures in the industrial sector can have a positive impact on the water withdrawals, such as:

- energy efficiency,
- utilising renewable energy,
- water efficiency,
- water reuse,
- removing water from production cycle.

In addition, industries can utilise by-products from municipal water systems that would normally be discharged into the environment.





Esholt IWWRR project (© Yorkshire Water)

FEATURE 1

INTEGRATED WATER, WASTE AND RESOURCE RECOVERY (IWWR)

The high level study focuses on developable land around the Kelda-operated Esholt Wastewater Treatment Works (WWTW) and its surrounding environment. The outputs suggest that gross revenue (excluding capital considerations) from the whole catchment could be increased by 40% over a 25 year period.

This excludes value derived from Natural Capital for example carbon, resilience, environmental and societal benefits. These additional values are anticipated to be significant. The value is based on low yield scenarios utilising conservative sensitivity factors.

IWWR is based upon systemic analysis of value creation options. The system includes assets, material flows, wider economic, social and natural systems within which Kelda operates. In essence the model delivers existing services (potable water and waste water services) more resiliently and sustainably plus new wholesale products (power, heat, nutrients and sub-potable water).

The study helped to articulate a vision of an integrated, systems led relationship between the environment, the company and its customers. Once delivered, it will deliver enhanced revenues from the current and new assets and delivery of sustainable focussed housing and improved amenity use of land.

The scope of the project include:

- Advanced thermal conversion using wastewater sludge coupled with locally sourced organic material to generate surplus heat, electricity and nutrients available for utilisation by local commercial and domestic properties.
- Mutually beneficial partnerships by attracting innovative industries to the 25 hectare land, e.g., local re-utilisation of by-products (heat, electricity, chemicals and nutrients), e.g., at the local industry and co-located vertical farm.
- Water reuse by treating and supply of water at various quality grades, both of potable and non-potable qualities, e.g. to co-located data centre and vertical farm.
- Re-purposing old sludge lagoon to 200,000 m^3 to create flood storage and natural habitat. The flood waters will be utilised as resource in the on-site developments, further reducing water abstraction.
- Creation of a sustainable village on 5 ha of land to maximise local resource reuse (heat, electricity, water).

(source: Kelda/Yorkshire Water)

FEATURE 2

WASTEWATER HEAT RECOVERY

The demonstration project is part of an EU Horizon 2020 funded Heat4Cool Project. The wastewater retains a significant portion of its initial energy that could be recovered and used every day. In this Heat4Cool project one of the main objectives is to harvest energy from wastewater generated by a block of buildings with integrated high performance and cost effective heat recovery technology. The recovered waste heat assists the AdHP and the DC powered Heat Pump to optimize their performances and reach values of 150% (GUE) and 5 (COP), respectively.

The project includes the design and realization of a heat pump based Thermowatt system that would use communal wastewater to heat and cool buildings around the St. Stephan Square in Budapest District 4. The climate is humid subtropical with annual average temperature 11.2 °C. The expected wastewater temperature is 15-20°C and the available wastewater flow is about 250 m^3/hour. Besides the already existing 1.7 MW Thermowatt system, a new 0.5 – 0.75 MW Thermowatt system is to be built that would serve three buildings with a total heated/cooled surface of 12 500 m^2: the Mayor's office (2 600 m^2), the Government Window (1 900 m^2) and the New Market Hall (8 000 m^2, under construction).

The annual final energy consumption is 274 kWh/ m^2, of which 197 kWh/ m^2 from natural gas and 77 kWh/ m^2 from electricity. The annual space heating and cooling demands are 178 kWh/ m^2 and 122 kWh/ m^2 respectively

(source: Thermowatt)

Waterless dyeing technology units (© DyeCoo)

FEATURE 3

WATERLESS DYEING IN TEXTILE INDUSTRY

Conventional textile dyeing is water intensive and generates highly polluted water that must be subject to costly treatment processes prior to discharge into rivers. A new commercial scale dyeing technology for synthetic fabric, DyeOx, has been implemented in Taiwan that uses carbon dioxide ($C0_2$) instead of water in the dyeing process. The technology uses no water, no auxiliary chemicals and reduced energy when compared to conventional processes.

The factory that is the subject of this case study installed two machines that produce 920 000 kg of fabric per annum and resulted in a reduction in water withdrawals of 8 256 000m^3 when benchmarked against conventional dyeing methods.

The technology was conceived at DELFT University and commercialized by the start up DyeCoo and Tong Siang Co., a dye-house in Thailand.

Nike, the global sportswear chain, recognizing the potential of the technology in helping to achieve its sustainability objectives, entering into a strategic partnership with DyeCoo in 2012 to implement the waterless dyeing technology in one of their Taiwanese factories. This led to a further three Taiwanese factories, who supply other major sportswear brands such as Adidas, making the investment decision to implement the technology.

(source: www.waterscarcitysolutions.org)

GEA Air cooled systems (© Eskom)

FEATURE 4

DIRECT DRY COOLING IN POWER SECTOR

Water resources are under considerable pressure in South Africa however they are critical for the production of electricity. Eskom, South Africa's and the African continents leading electricity supplier is a government owned utility that provides electricity to almost 95% of all end users in South Africa, and close on 60% of the entire electricity consumption on the African continent.

Eskom's coal fired power stations are steam driven using highly purified water and there is an effort to recover and re-use water due to the high costs in production and water scarcity. Eskom have a zero discharge policy and water is only lost from the plants during the condensation of the spent steam and as ash slurry.

In the financial year of 2010/11, the Eskom fleet consumed a total of 327 million m^3 of water during the power generation process. If innovative technologies for more efficient cooling using less water had not been implemented, this consumption would have been at 530 million m^3

Matimba Power Station in the Limpopo Province is an example where direct dry cooling has been implemented to reduce water consumption. Limpopo Province is one of South Africa's richest agricultural areas but also particularly dry and unable to meet its water needs from its local supplies. Matimba Power Station is the largest direct-dry-cooled station in the world, with an installed capacity of greater than 4 000MW. It makes use of closed-circuit cooling technology reducing water consumption to around 0.1 litre per kWh of electricity distributed.

The main driver for this intervention was the medium to long-term water resource security. This is under threat due to conflicting demands for the right to use water, depleted environmental flows, population and economic growth and the implications of climate change.

(source: www.waterscarcitysolutions.org)

FEATURE 5

ENERGY POSITIVE WASTEWATER TREATMENT

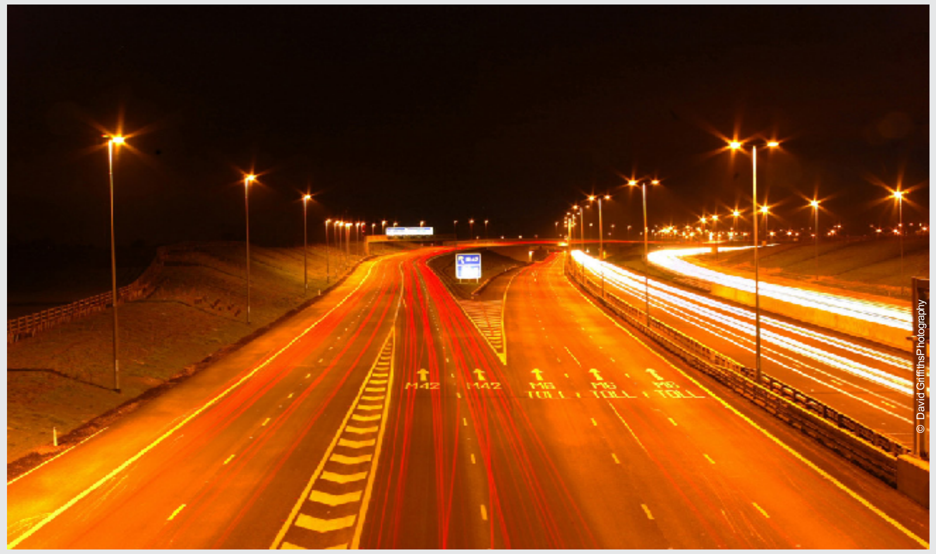
Wastewater treatment has a significant associated energy demand. In the US, this has been estimated as 0.5% of overall demand equivalent to USD1.3billion. In India, the cost of not treating wastewater, has been estimated as USD54billion, the main reason is costly or unreliable energy supplies.

An analysis of the chemical and heat energy within wastewater reveals that there is up to 14 times more embodied energy than that required for treatment. Although much of this is low grade heat, it should still be theoretically possible to achieve an energy positive treatment plant.

In the Danish city of Odense, utility company VCS has turned this theory into reality. The Ebjy Mølle treatment plant, treats a population of almost 400,000 and has achieved an energy positivity of 150 percent, so that rather than draw down, instead it exports electricity and heat to the local network.

The transformation was made possible by careful analysis of historical operational data which identified a series of energy optimization options, many of which were implemented just with modifications in operational strategies rather than significant equipment upgrades. Since making the initial changes, a number of further facility improvements were implemented that so that on occasions 200% energy positivity is achieved.

The technical interventions were grounded on the adoption of a very clear ‘carbon neutrality’ mindset across the organisation. This in turn led to the development and commitment to a very aggressive corporate environmental targets.



FEATURE 6

NUTRIENT RECOVERY AND WATER REUSE

Tirupur is a mid-sized industrial town located in the upper hydrological basin of the Cauvery River, a highly polluted water body due to industrial discharges affecting the agricultural potential of downstream lands.

As part of compliance with Government requirements, Tamil Nadu Water Investment Company (TWIC) installed nine effluent treatment plants operated to treat 922 000 m^3/yr of effluent from 200 textile industry units. These plants were upgraded with Reverse Osmosis units enabling re-use of 96% of the effluent.

In addition Thermal Evaporation units were installed to capture and extract dye salts, which were re-sold to the industry adding another revenue stream for TWIC as well as reducing the consumption of virgin salts.

This project enabled the industry to substantially reduce its demand on scarce water resource with 75% of the total water demand now met by reclaimed water. The reduction in abstraction by 876 000 m^3/yr has improved the availability of water for other users and has been specifically welcomed by the local farmers.

The various elements of the project satisfy the three principles of circular economy, although at a significant operational energy costs. There is further potential to enhance the circular economy credentials of the project by utilising renewable energy to further reduce the environmental impacts of the industry.

(source: www.waterscarcitysolutions.org)

FEATURE 7

THE UPPER TANA-NAIROBI WATER FUND

The Tana River supplies 95% of Nairobi's 4 million residents, it also feeds the country's agricultural areas and provides 50% of the country's hydropower input. Nairobi contributes to 60% of the country's GDP, so the river could be viewed as the prime mover for Kenya's economic growth.

Since the 1970's, the steep sided forested slopes of the Upper Tana catchment have been cleared for agriculture, resulting in millions of tons of soils washing down the river, choking up reservoirs and treatments plants, leading to high annual desilting costs along with constant disruptions to power and water supply.

To address this issue systemically, the Nature Conservancy, a US conservation NGO, established the Upper Tana Water fund, founded on the principle that is cheaper to prevent water problems at the source (causes) than downstream (symptoms). Donors include major downstream water users, the fund supports soil conservation measures in the upstream catchment.

The fund and its partners work with nearly 15,000 farmers providing the training resources and equipment so that they can cultivate crops in a way that keeps the river healthy, conserves water and allows higher yields and profits.

The fund's business case estimates that the USD10 million dollar investment is likely to yield USD21.5 million in economic benefits over a 30-year time frame.

CONCLUSION

REALISING THE POTENTIAL

The dimensions of water as a Carrier, Energy source and Service provider are not exclusive and overlap exist across them. For example, in cities wastewater conveys human/organic wastes whilst at the same time can be harnessed as a source of thermal energy. This confluence is central to the opportunity that circular economy offers the water sector.

Humans have learned to harness the natural environment and develop their own man-made environments to realize value from the dimensions of water. These activities are not always undertaken in the most resource efficient and regenerative way.

Utilisation of a systems approach and taking into account the local environmental conditions will better enable the identification of opportunities and required outcomes as well as in evaluating impacts and any multiple benefits.

This White Paper proposes that the circular economy lens can bring a new viewpoint to our man-made managed water systems, and to the way that they are designed and operated.

The circular economy lens has the potential to change the value proposition of the system under consideration whilst ensuring that its purpose and function is still delivered.

It creates a shift that seeks value from the wider system rather than just from the fixed point at which consumption applies. Functional requirement will still be met; at the same time as creating value from resource efficiency and water use dimensions of service energy and carrier. Digital technology and innovative business practice help realize this.

In this way the application of circular economy principles can help us meet the step changes to practice that will be necessary for it to meet future water demands, whilst facing key challenges access to resource, increased demand, and more stringent quality and pollution and environmental controls.

THE OPPORTUNITY

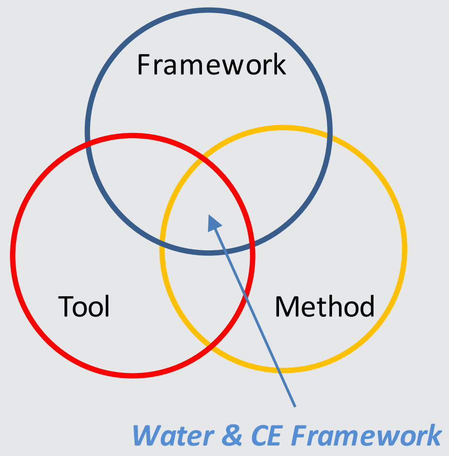
EVALUATION & ASSESSMENT

Within the water and circular economy communities, there are a broad range of assessment tools, initiatives, project approaches and other methods that may be effective starting points to establishing a framework that links water and circular economy.

The ReSOLVE framework provides an overarching approach that exemplifies the concepts of circular economy. Some of other existing frameworks are listed in the table below.

To enable assessment of an organisation for potential value extraction or generation, there is a need to either develop a new framework or adapt current frameworks.

The framework should include method and tools to enable the assessments. This will require further investigation.



Initiative / Tool / Framework	Organization	Link to Water & CE
ReSOLVE	McKinsey / Ellen MacArthur Foundation	Related to service and medium dimensions of water
Water Utility Pathways in circular economy	International Water Association (IWA)	Perspective of CE from water utility perspective
7s Model – circular economy & Buildings	Arup	Provides holistic approach to CE assessments
AWS Standard	Alliance for Water Stewardship	Water resources, water quality
Performance in Watershed Context:	Beverage Industry Environmental Roundtable (BIER)	Water resources, economics
Disclosure Initiatives for Cities and Water:	Carbon Disclosure Project (CDP)	Water footprint, sustainable water use
Water Risk and Action Framework (WRAF)	International Water Stewardship Programme (IWaSP)	Sharing of resources in participatory manner
InVEST & RIOS Ecosystem Health Assessment:	Natural Capital (NatCap) Project	Ecosystem services, carbon and economics of solutions

NEXT STEPS – PHASE 2

FURTHER CO.PROJECTS IDEAS

COMPENDIUM OF CASE STUDIES

The case studies compendium will collate the examples of projects where circular economy thinking has been applied to systems where water is the primary function, e.g. municipal, industrial or urban water and wastewater, as well as where water provides a specific service as part of the system operation or production (i.e., the Dimensions of Water discussed in previous sections).

These case studies will help to identify the variety of measures that are available, the quantification of the benefits, and the nature of the additional value that has been generated.

These case examples will help establish the context and content of an appropriate Water & circular economy Framework.

WATER & CIRCULAR ECONOMY FRAMEWORK

The dimensions of water as a Carrier, Energy source and Service provider are not exclusive and confluences exist across them. For example, in cities wastewater conveys human/organic wastes whilst at the same time can be harnessed as a source of thermal Energy. This confluence is central to the opportunity that circular economy offers the water sector.

Humans have learned to harness the natural environment and develop their own man-made environments to realize value from the dimensions of water. These activities are not always undertaken in the most resource efficient and regenerative way.

Utilisation of a systems approach and taking into account the local environmental conditions will better enable the identification of opportunities and required outcomes as well as in evaluating impacts and any multiple benefits.

URBAN BIOLOOP + ENERGY POSITIVE WASTEWATER TREATMENT

A city's built environment includes the hard infrastructure for its function, such as a wastewater treatment plant.

The city also relies upon the urban green spaces that provide a multitude of benefits to its residents.

Both systems are interlinked by multiple circular economy streams of water, nutrients, food, and materials.

This Co.Project would explore the interaction between the two, identify where further value can be created and how to find balance between the two objectives.

WATER & CIRCULAR ECONOMY MATURITY ASSESSMENT

A maturity assessment will identify the knowledge and awareness of water and circular economy within an organisation.

Water is ubiquitous and water systems directly and indirectly interact with most of the other systems.

Due to this ubiquity, even where an organisation does not have direct interaction with water, it may be able to affect a positive change on the water and circular economy system and derive additional value.

CO.PROJECT WORKING GROUP

Project Leads

Water and Wastewater Treatment

Food & Beverage Industry

Other Industries

Academia and Government

Others

PROJECT TEAM

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. With over 80 offices in 34 countries Arup has more than 14,000 planners, designers, engineers and consultants delivering innovative projects across the world with creativity and passion.

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The Ellen MacArthur Foundation was launched in 2010 with the aim of accelerating the transition to the circular economy. Since its creation, the charity has emerged as a global thought leader, putting the circular economy on the agenda of decision-makers across businesses, governments, and academia. The charity's work focuses on five interlinking areas: insight and analysis; learning and training; business and government; systemic initiatives; and communications.

www.ellenmacarthurfoundation.org
@circulareconomy

Antea Group is an international engineering and environmental consulting firm specializing in full-service solutions in the fields of environment, infrastructure, urban planning and water. Antea has 3,500 employees in over 100 offices around the world, serving clients ranging from global energy companies and manufacturers to national governments and local municipalities

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