



Water Cycle Management for Building Water-Wise Cities

水循環管理に基づく「ウォーター・ワイズ都市」構築

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Outline (概要)

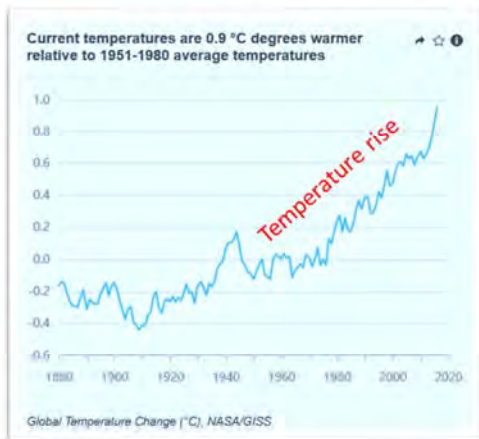


- Background (背景)
- Things we can learn from the hydrological cycle (自然の水循環系から学べること)
- Concept of *Water Cycle Management (WCM)* (水循環管理のコンセプト)
- Application of *WCM* concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)
- Application of *WCM* concept for building a decentralized water system (分散型水循環システムへの応用例)
- Concluding Remarks (まとめ)

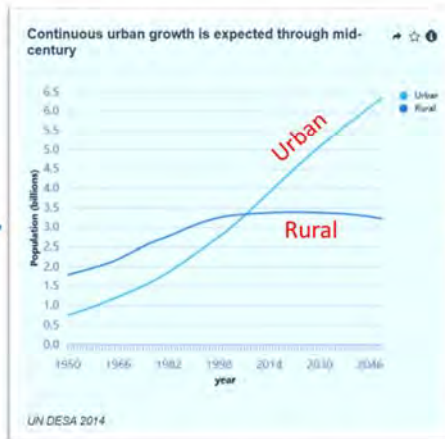
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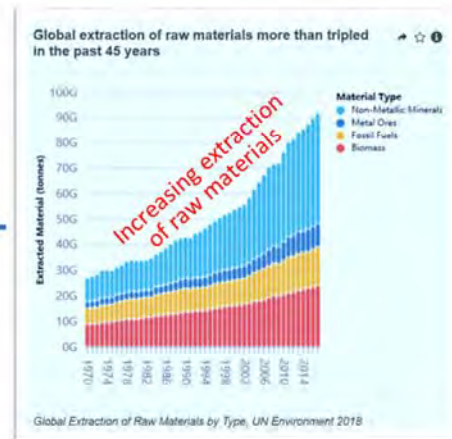
● Global Issues (世界的な問題)



Climate Change
気候変動



Population Growth & Urbanization
人口増と都市化

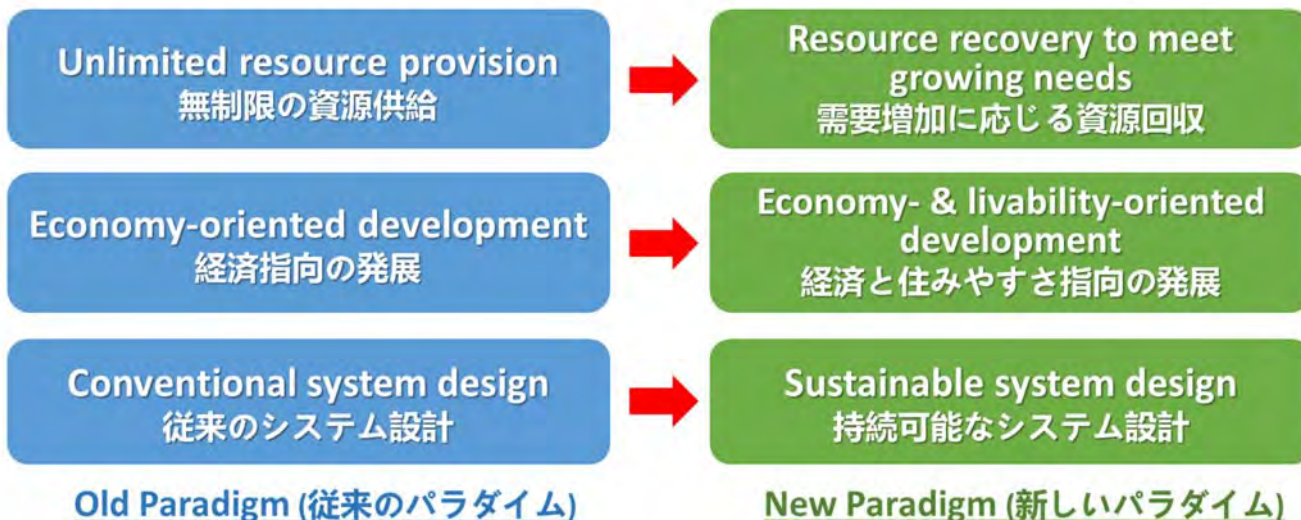


Limited Resource & Increasing Use
有限資源の使用増加

Background (背景)



● Urgent Needs for Paradigm Shift (パラダイム・シフトの必要性)



Background (背景)



● IWA Cities of the Future (CoF) Program (国際水協の「未来都市」計画)

- ✓ Urgent changes needed to respond to *climate change, population growth, growing resource constraints, and rapidly increasing global urbanization.*
- ✓ The city of the future must *integrate water management planning and operations with other city services* to meet the needs of humans and the environment in a dramatically superior manner.

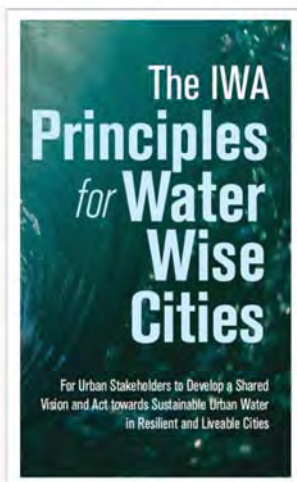
Launched in 2009 (2009年発足)
to meet the needs for a different approach
to urban water management



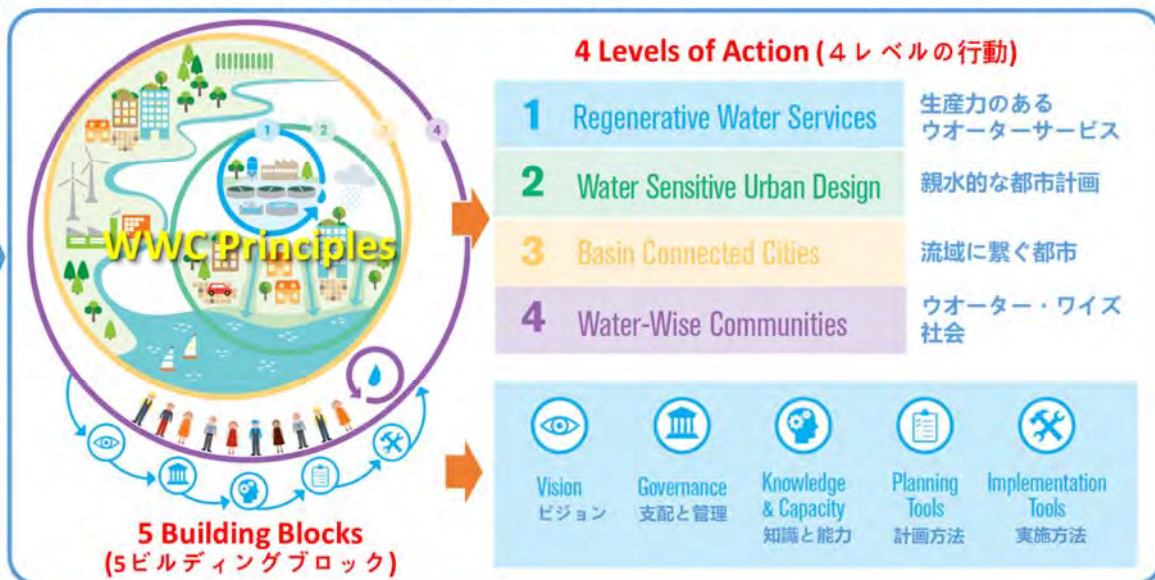
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● IWA Principles for Water Wise Cities (IWAウォーター・ワイズ都市原則)



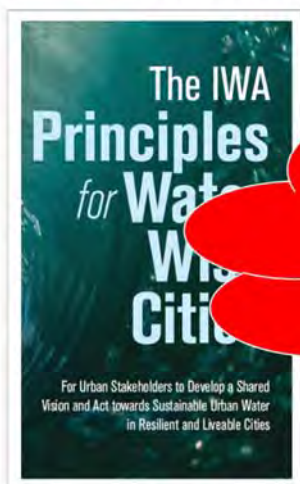
Launched in 2016
Reinforced in 2018



Background (背景)



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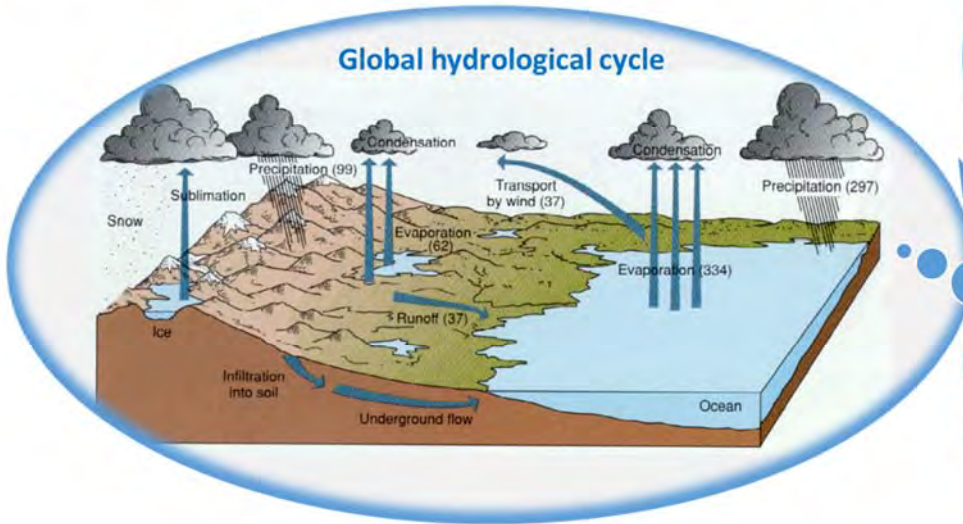


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Things we can learn from the hydrological cycle (自然の水循環系から学べること)



● Global hydrological cycle (グローバルな水循環系)



- Natural processes driven by solar energy
- Under a dynamically equilibrium condition

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Things we can learn from the hydro-logical cycle (自然の水循環系から学べること)



● Global hydrological cycle (グローバルな水循環系)

- The hydrological cycle can be viewed as a “Sponge” with sufficient water space (自然の水循環系は、十分な水域を有する「スポンジ」とみなせる)
- Water in each part of it is quantitatively and qualitatively stable under a dynamically equilibrium condition (各部分の水は動的平衡状態に基づき、量的かつ質的に安定である)

Unit: 10^3 km^3

| Waterbody | Fresh water stored | Waterbody | Fresh water stored |
|---------------------|--------------------|-------------------|--------------------|
| Groundwater aquifer | 10 530.0 | Atmospheric water | 12.9 |
| Lake water | 91.0 | Marsh water | 11.5 |
| Soil water | 16.5 | River water | 2.1 |

Things we can learn from the hydro-logical cycle (自然の水循環系から学べること)



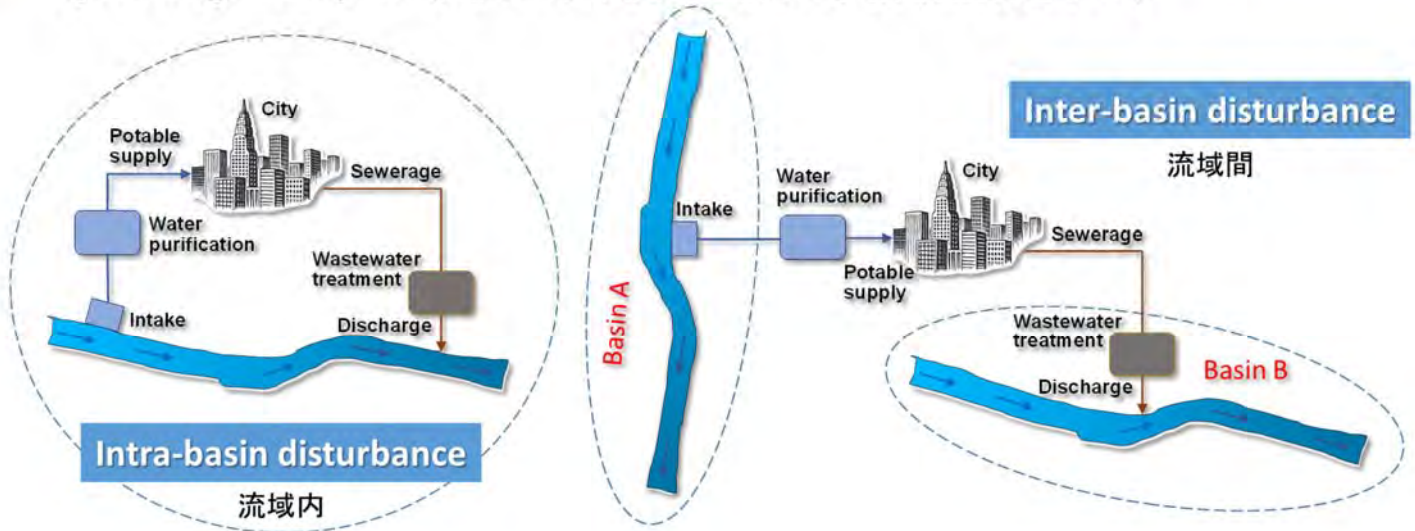
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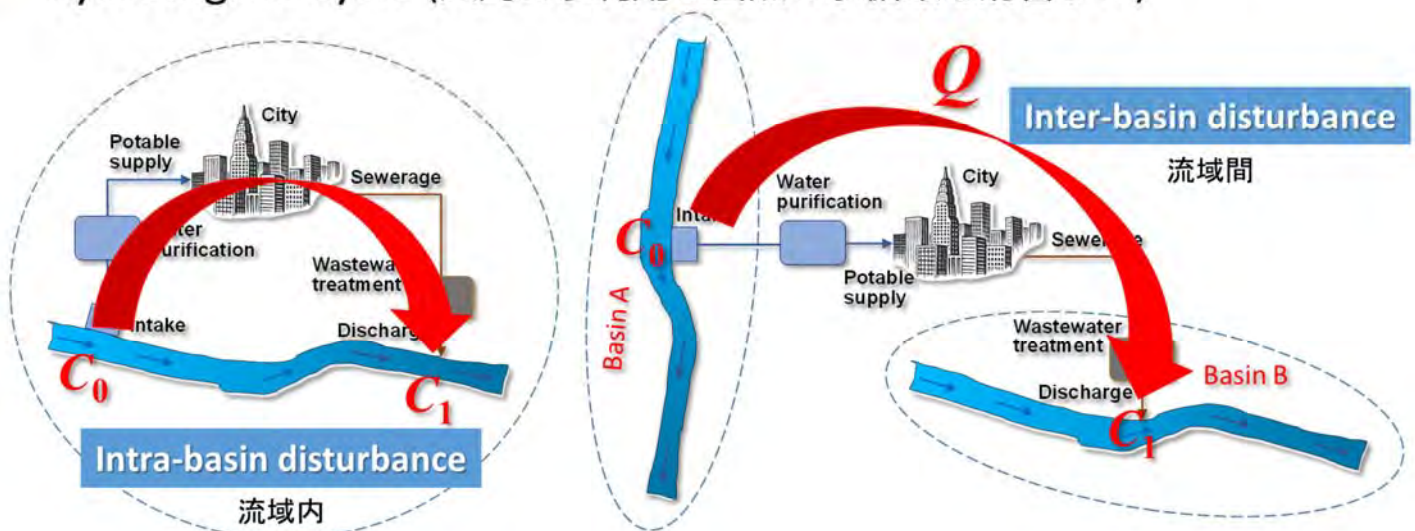
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Things we can learn from the hydro-logical cycle (自然の水循環系から学べること)



- Sufficient clean water sources are primarily sustained by the natural water cycle (上質な水資源は、自然の水循環に支えられた)



Fully depended on natural purification

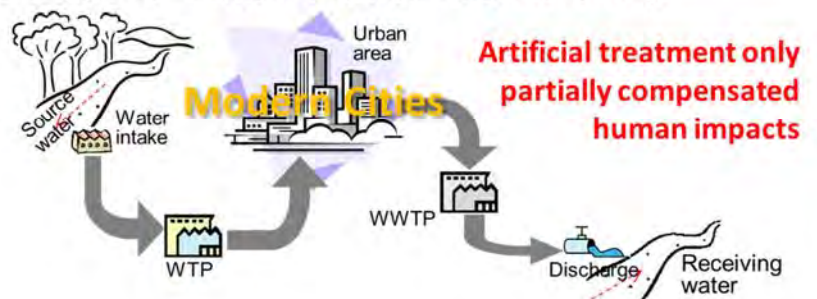
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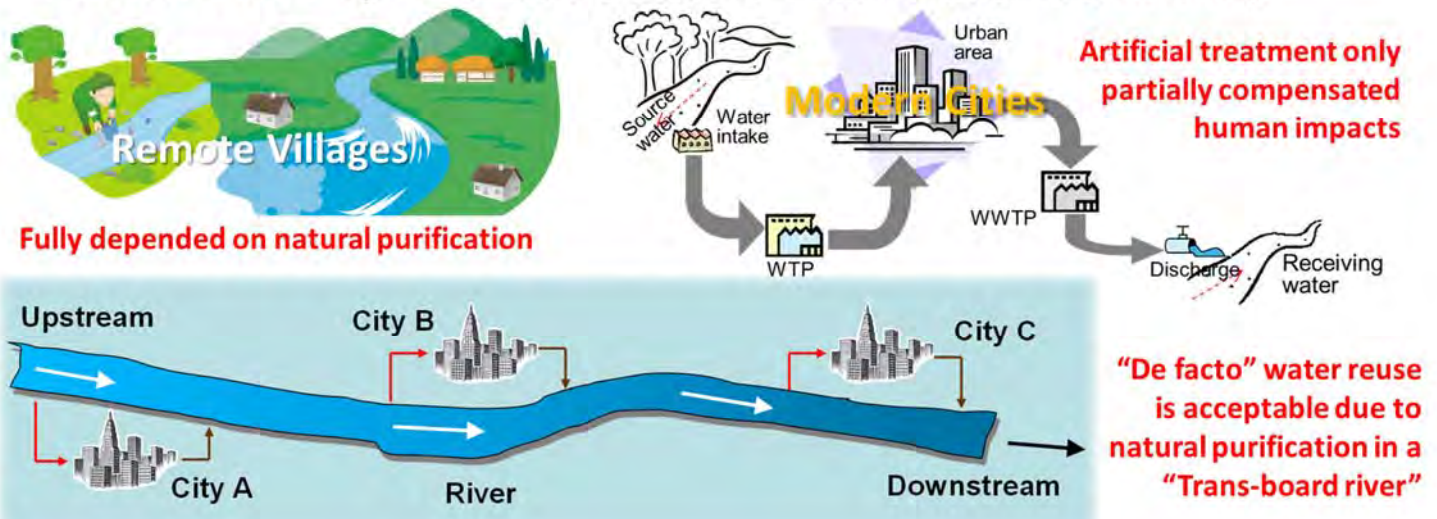
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Concept of Water Cycle Management (WCM) (水循環管理のコンセプト)



- Important things lack of full awareness by water professionals
(専門的認識の不足点)

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 - The starting point of urban water system planning and construction must be changed from fully satisfying human needs to following natural laws (都市水系再構築の出発点は、人間の需要を満足する方式から自然法に従う方式へ転換すること)

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Proposal of the concept of Water Cycle Management (WCM)

Concept of Water Cycle Management (WCM) (水循環管理のコンセプト)



- Characteristics of the natural water system (自然的水循環の特徴)

1

Driven by solar energy
– therefore associated
with green processes
(太陽エネルギーに駆動される
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Concept of Water Cycle Management (WCM) (水循環管理のコンセプト)



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Driven by solar energy – therefore associated with green processes (太陽エネルギーに駆動されるグリーンプロセス)

2

Under dynamic equilibrium condition – a thermodynamically sound system (動的な平衡を常に満たす理想的な熱力学系)

Concept of Water Cycle Management (WCM) (水循環管理のコンセプト)



● WCM principles (水循環管理の原則)

Water Cycle Management
(水循環管理)



- To maintain the hydrological cycle as it is, as far as possible (自然の水循環系を、可能な限り維持すること)
- To follow the nature's manner, as far as possible, in system design and technology selection/integration (システム設計と技術選択と統合において、可能な限り自然の方式に従うこと)

Concept of Water Cycle Management (WCM) (水循環管理のコンセプト)



- WCM can bring about paradigm shift for urban water planning (水循環管理は都市水計画のパラダイム・シフトをもたらす)



Old Paradigm

Nature dependent

Concept of Water Cycle Management (WCM) (水循環管理のコンセプト)

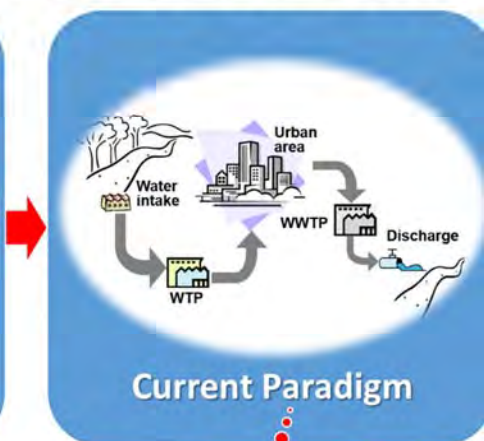


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Old Paradigm

Nature dependent



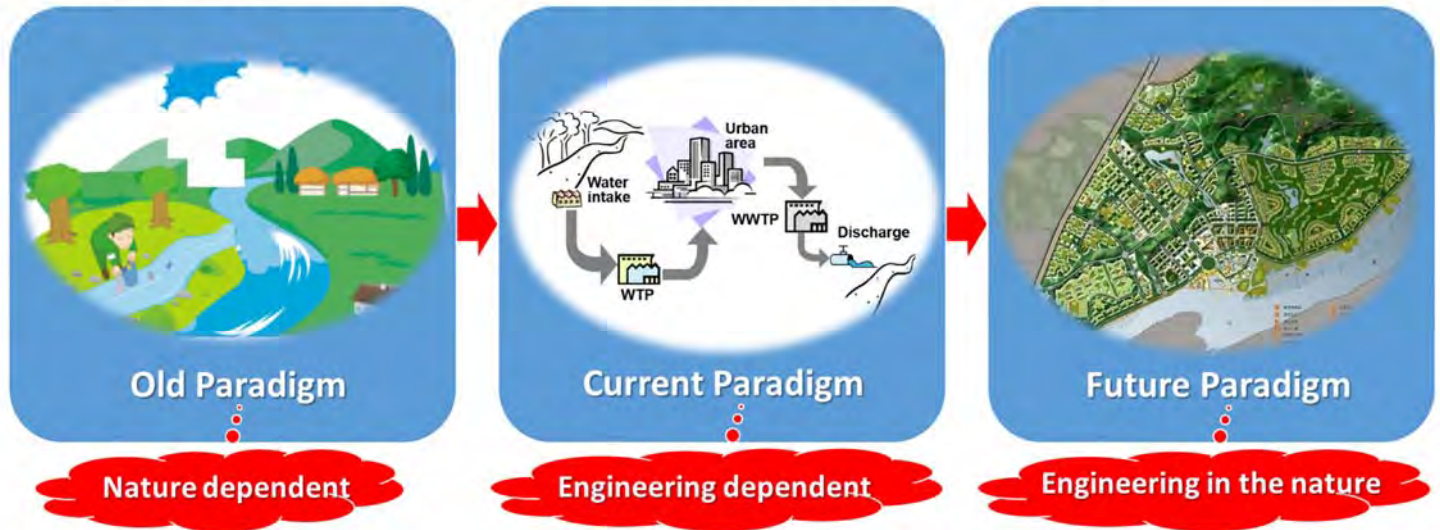
Current Paradigm

Engineering dependent

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Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



- The “Eight-Rivers Regeneration” project in Xi’an (西安市「八水回復」プロジェクト)



Historical view of
“Eight Rivers
Surrounding the
Capital”
「8つの川が長安を取り
囲む」歴史

Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)

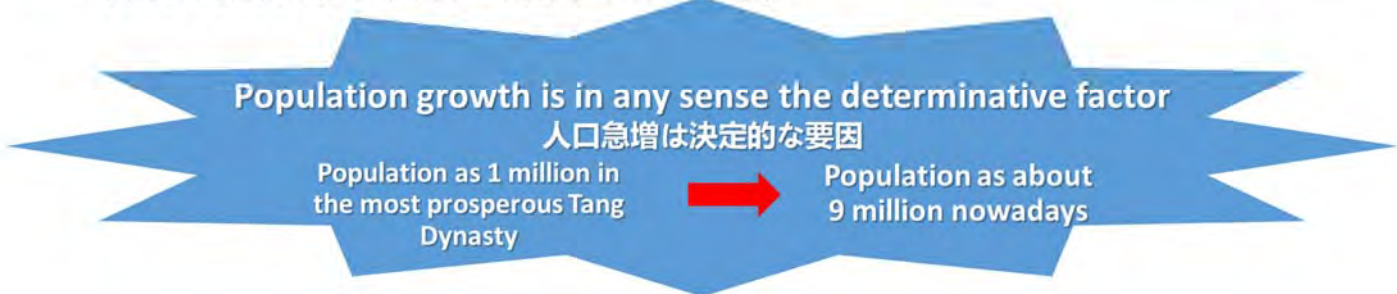


- The historical beauty of a “Water City” disappeared due to (「水都市」の歴史的美しさは消えた原因)
 - ❑ Climate change resulting in lower precipitations (気候変動による雨量低減)
 - ❑ Increasing abstraction of water from river channels for various water uses (用水増加による河川水位の低下)
 - ❑ Unreasonable application of river channels in the past decades (過去数十年間、河川水路の不合理的利用による破壊)

Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



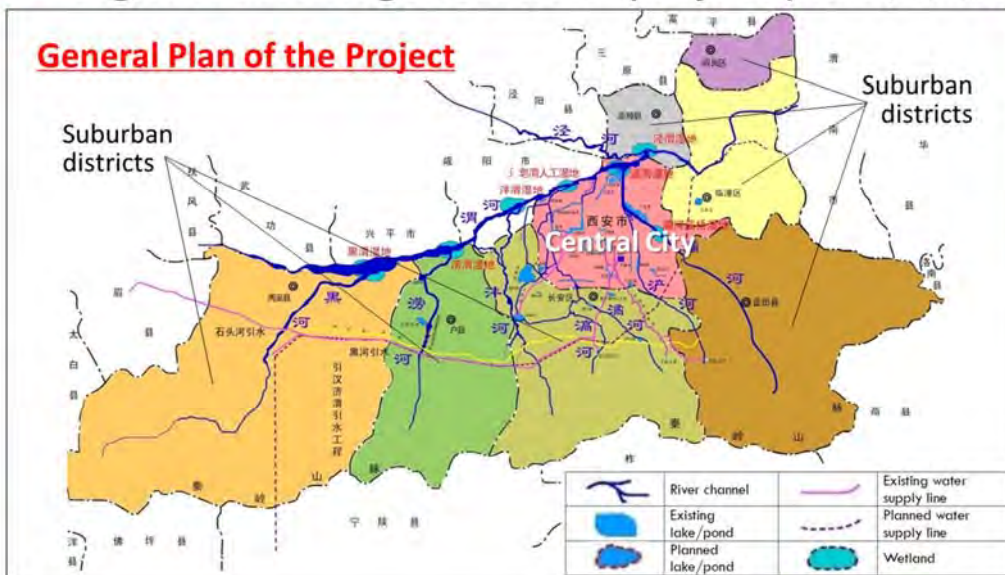
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Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



- “Eight-Rivers Regeneration” project plan (「八水回復」計画)

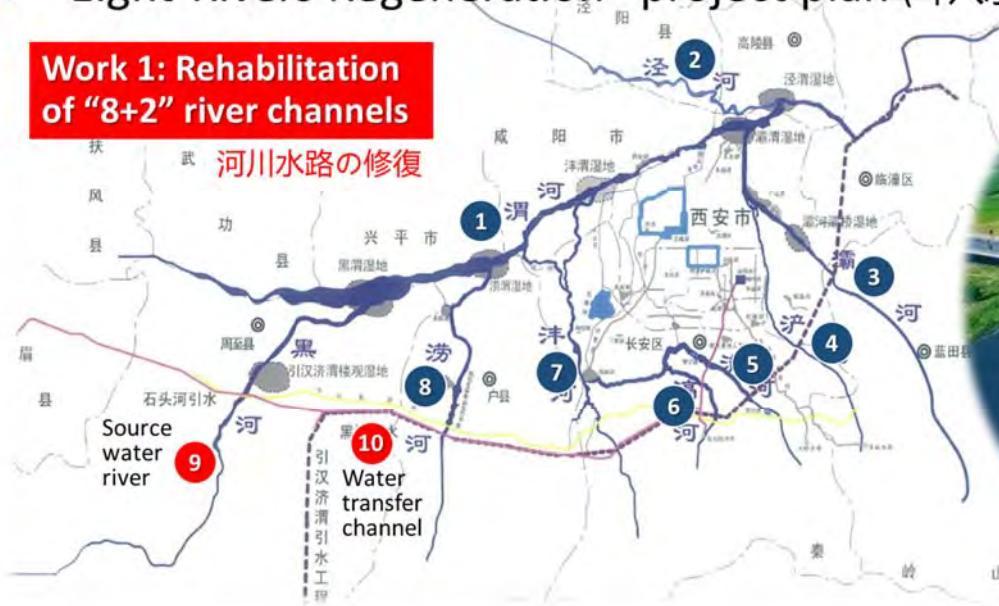


Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



● “Eight-Rivers Regeneration” project plan (「八水回復」計画)

Work 1: Rehabilitation of “8+2” river channels

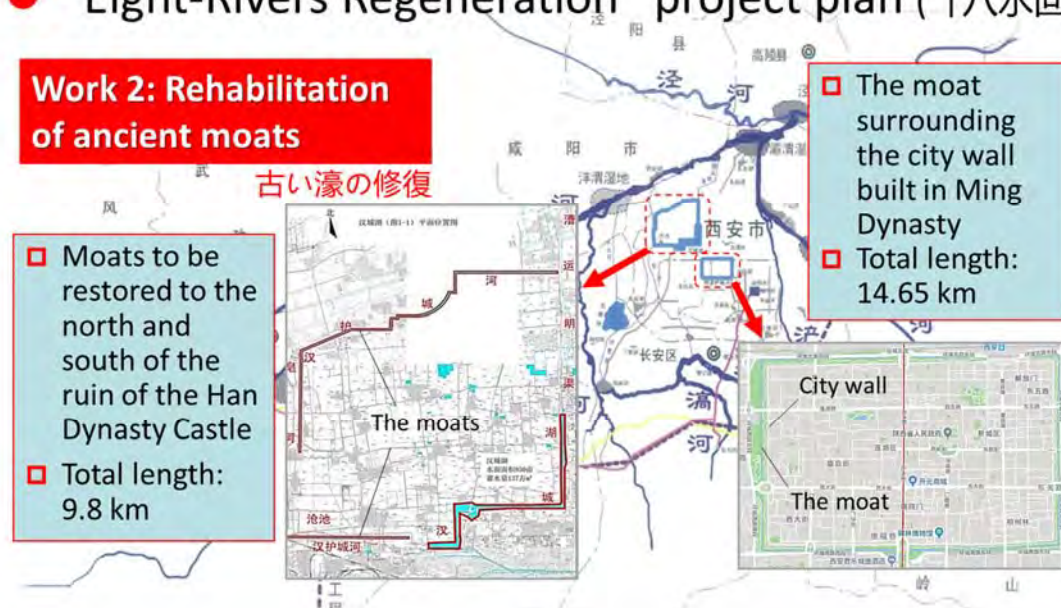


Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



● “Eight-Rivers Regeneration” project plan (「八水回復」計画)

Work 2: Rehabilitation of ancient moats



- Moats to be restored to the north and south of the ruin of the Han Dynasty Castle
- Total length: 9.8 km

- The moat surrounding the city wall built in Ming Dynasty
- Total length: 14.65 km



Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



● “Eight-Rivers Regeneration” project plan (「八水回復」計画)

Work 3: Restoration of urban lakes

都市湖・池の復元

- ❑ 28 urban lakes to be restored/rehabilitated
- ❑ Total surface area: 2070 ha
- ❑ Total storage volume: 62.2 million m³



Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



● “Eight-Rivers Regeneration” project plan (「八水回復」計画)

Work 4: Wetland construction adjacent to rivers

河川に隣接する湿地帯建設



Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



- Restrictions for the project implementation (実施を制限する要因)
 - ❑ Natural precipitations are no longer as plenty as centuries ago (自然の降水量は、昔ほどの豊富さではない)
 - ❑ Some rivers do not have perennial flow (一部の河川は、常時に流れていない)
 - ❑ All the rehabilitated lakes/ponds need artificial impoundment and/or replenishment (復元した都市湖沼は、人工給水が必要)
 - ❑ Current water shortage is a critical bottleneck (水不足はボトルネックになる)

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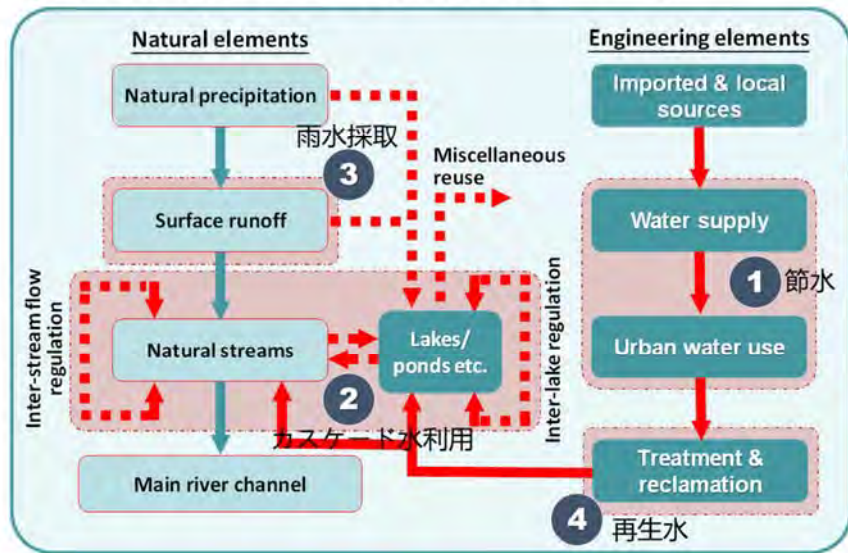
Needs for formulating an integrated water management plan to optimize utilization of all applicable water sources

総合的な水管理プランが必要

Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



- Water source enlargement plan following the WCM principle (水循環管理に基づく水源拡大プラン)



準自然水循環系の構築

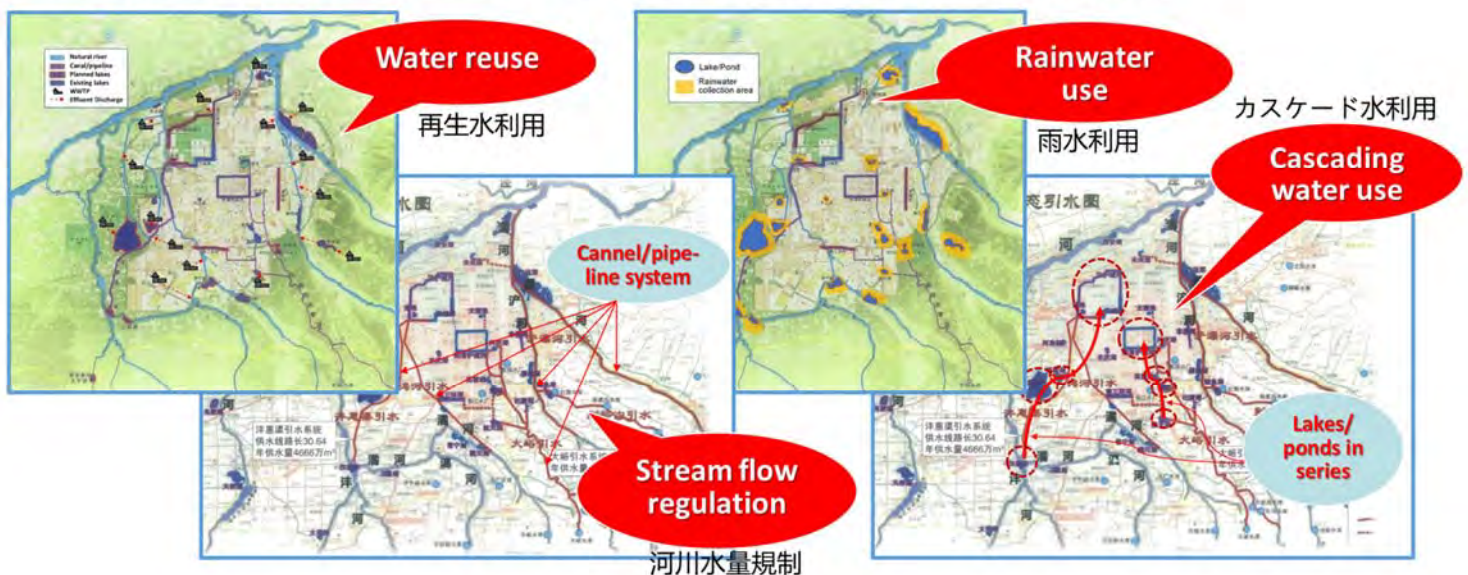
A quasi-natural water cycle with

- ① Water saving (節水)
- ② Multi-functional and cascading water use
- ③ Rainwater harvesting (雨水採取)
- ④ Water reclamation as *four pillars* to support integrated water management (四本の柱)

Application of WCM concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)



- Engineering plan for source enlargement (水源拡大対策)



Application of WCM concept for planning a water-wise city (ウオーター・ワイズ都市計画への応用例)



- Water supply for lakes/ponds replenishment by various sources (湖・池補給のための給水プラン)

| Water source | Annual supply (million m ³ /yr.) | Percent of supply (%) |
|------------------------------|---|-----------------------|
| Natural stream flow 自然河川水 | 104.85 | 41.9 |
| Cascading water use カスケード水利用 | 49.55 | 19.8 |
| Rainwater harvesting 雨水利用 | 23.52 | 9.4 |
| Water reclamation 再生水 | 72.32 | 28.9 |
| Total | 250.24 | 100 |

Natural stream flow utilization only takes 41.9% of the total water supply while 58.1% has been covered by alternative water sources

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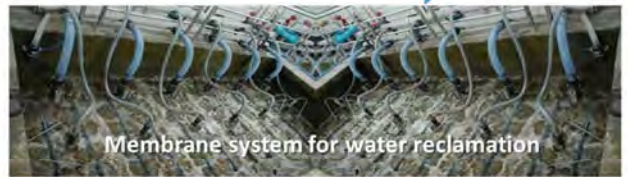
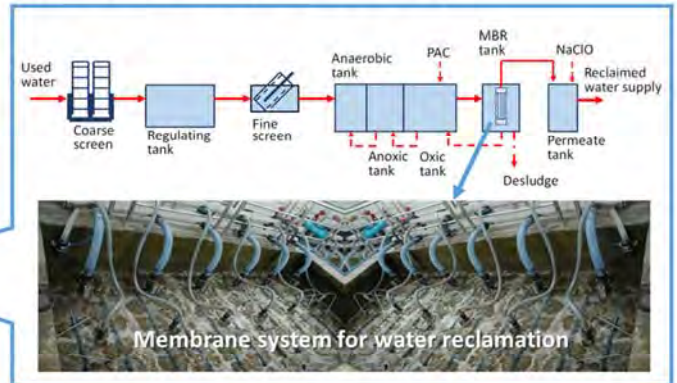
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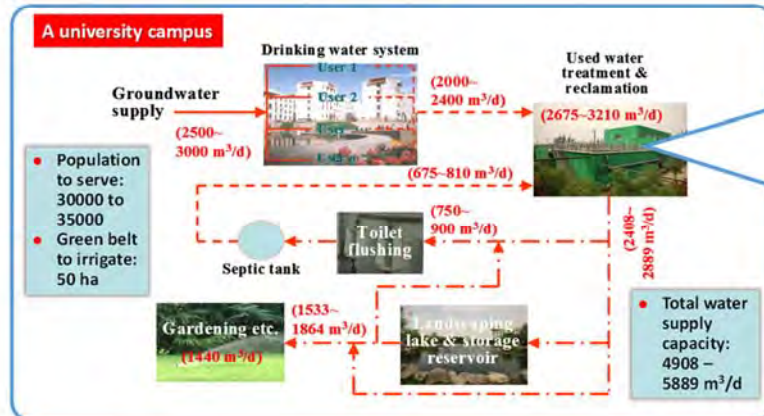
- A decentralized system for maximizing water reuse efficiency through a water cycle (水循環による水再利用効率を最大化する分散型システム)

- ❑ Limited groundwater only for drinking (地下水で飲料水供給)
- ❑ Reclaimed water for all non-potable supplies (再生水でトイレ洗浄、緑地灌漑、景観用水供給)



Membrane system for water reclamation

- ❑ Operation started in early 2011 and the system is now still serving the campus (2011年稼働開始)
- ❑ Long term monitoring has continued for 8 years (8年間モニタリング)



Application of WCM concept for building a decentralized water system (分散型水循環システムへの応用例)

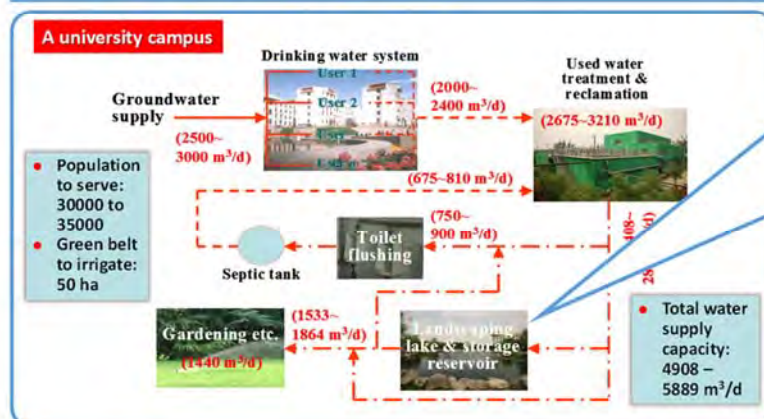


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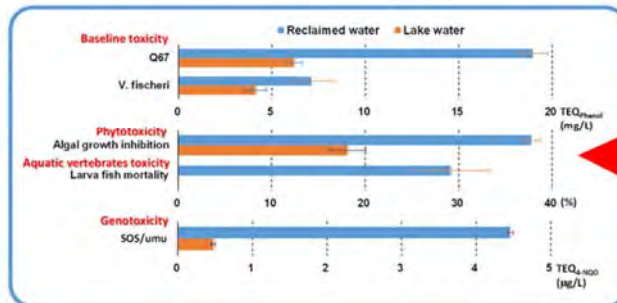
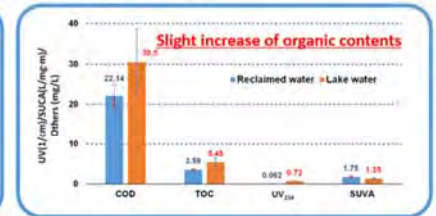
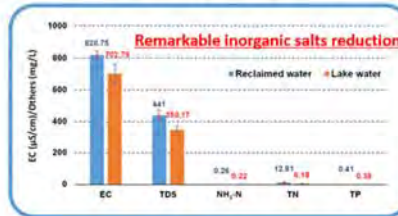
Application of WCM concept for building a decentralized water system (分散型水循環システムへの応用例)



- A decentralized system for maximizing water reuse efficiency through a water cycle (水循環による水再利用効率を最大化する分散型システム)



Lake for landscape and as a reservoir

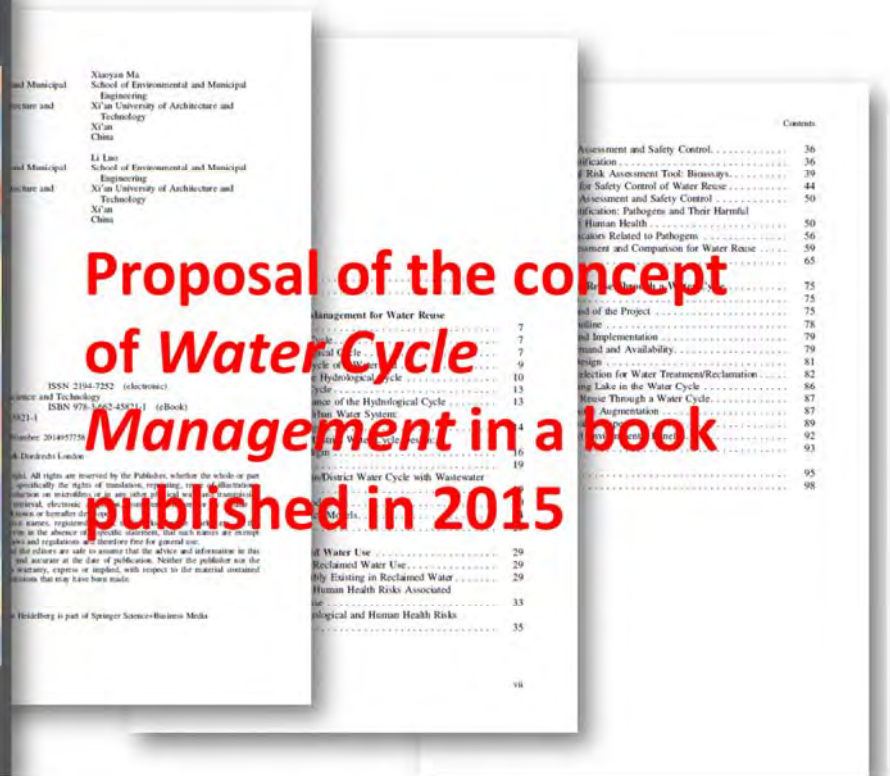
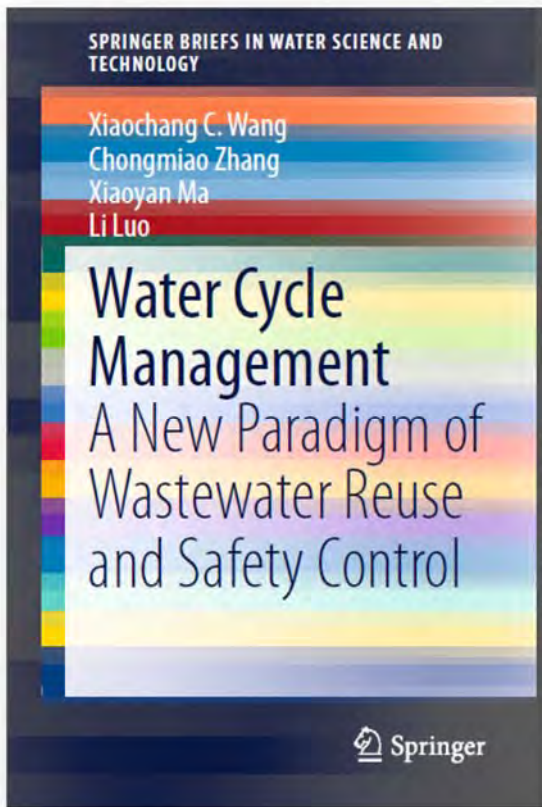


- Green campus nourished by reclaimed water (再生水で維持したグリーンキャンパス)
- Safety supply ensured by combing engineering with ecological means (処理施設 + 生態系による水質確保)

IWA Global Project Innovation Award 2012
Green Campus Nourished by Reclaimed Water – Decentralized System of Zero Discharge and Maximized Water Reuse

国際水協アワード受賞





Outline (概要)



- Background (背景)
- Things we can learn from the hydrological cycle (自然の水循環系から学べること)
- Concept of *Water Cycle Management (WCM)* (水循環管理のコンセプト)
- Application of *WCM* concept for planning a water-wise city (ウォーター・ワイズ都市計画への応用例)
- Application of *WCM* concept for building a decentralized water system (分散型水循環システムへの応用例)
- Concluding Remarks (まとめ)

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- Cites are water-basin connected and depend on hydrological cycle for water sources (都市は流域に依存、自然の水循環によって水資源が確保)

Concluding Remarks (まとめ)



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Concluding Remarks (まとめ)



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- Two principles: (1) to maintain the hydrological cycle as it is and (2) to follow the nature's manner (水循環管理の原則: 自然の水循環系の維持すること + 自然の方式に従うこと)

Concluding Remarks (まとめ)



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- Two important roles of WCM: (1) Water source augmentation and (2) Water quality improvement (水循環管理の機能: 水資源拡大 + 水質改善)

