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Shifting climate, reshaping urban landscapes : designing for drought in the Campine landscape

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Abstract

As global warming persists, regions with moderate climatic conditions will be confronted with exacerbating seasonal variations, including aggravating dry periods. This upcoming drought challenge receives, however, little attention by policy makers. Likewise, Flemish planners and designers focus on floods, not droughts. This research concentrates on design strategies to deal with a lack of water in highly urbanised territories such as Flanders. The article analyses the results of a design workshop on (future) drought issues in the Campine region; *Shifting Climate, Reshaping Urban Landscapes*. Four distinct strategies are delineated: 'remodeling the valleys', 'retrofitting urbanisation', 'aqueducts 2.0' and 'autonomous, local water networks'. The article discusses the premise of each strategy and its approach to the local landscape and urban tissue. Moreover, it highlights key issues to drought design in highly urbanised territories.

Drought, a forgotten climate challenge

Climate change is widely recognized as a key issue of the twenty-first century. The International Panel on Climate Change (IPCC) warns global warming will cause multiple droughts; meteorological droughts agricultural droughts, hydrological droughts and water supplies under pressure (Jiménez Cisneros et al. 2014). Accordingly, territories must be prepared for an increasing lack of water. In water scarce regions climate change will aggravate current drought issues.

The drought challenge is, however, not limited to these 'dry' regions. Climate research forecasts additional seasonal variation in precipitation and exacerbating weather extremes in the moderate climate of north-western Europe (Kovats et al. 2014). Consequently, summer droughts are expected to occur more frequently and to last longer. Likewise, nearly all climate models forecast additional seasonal variation in precipitation for Flanders, the northern part of Belgium (Van Lipzig and Willems 2015). As a result, the local water availability is likely to change; wetter winters and drier summers by the end of the 21st century (Tabari, Taye and Willems 2015).

In the light of the upcoming climate challenges, the European Commission emphasizes the need for water administrations to address both droughts as well as floods (COM 2012). In practice, however, climate adaptation [1] is mostly limited to actions in the context of current hazards (Patt 2013). The coastal defence in the United States, for example, was only revised after the devastations caused by super storms Katrina and Sandy. Moser (Moser 2010) speaks of an 'alarm reflex'; topical, dramatic weather events dominate the public attention and the policy work.

Within the Flemish context fluvial and pluvial flooding are the most pressing issues and tend to dominate the adaptation debate. In contrast, there is little public awareness or policy work [2] on drought in Flanders (Bressers 2015). Likewise, Flemish planners and designers are mainly preoccupied by flood issues, not the upcoming drought challenge. In other words, drought is a somewhat forgotten climate challenge.

Water design

1) Floods restructuring sprawl

The current flood issues in Flanders are to a great extent due to the high urban sprawl. And as urbanization continues at the breakneck speed of 6 football pitches a day (Poelmans and Engelen 2014), the little remaining open space is under persistent pressure. More specifically, as a result of the

widespread urbanization in the alluvial plains, there are little natural floodplains left to help regulate fluvial flood risks. Each winter, rain falls persistently during multiple days and one or more of the Flemish rivers bursts its banks, flooding adjacent residential, industrial and agricultural areas. On the other hand, each summer, storms provoke pluvial flooding in urban and peri-urban areas, as too many soils are sealed. Both flooding phenomena are expected to aggravate as a consequence of climate change (Van Lipzig and Willems 2015).

In the recent past, flood management was the somewhat exclusive domain of hydraulic engineering that tends to focus on technical interventions such as buffer basins. Current research and policy, however, favour a new approach; the so-called Integrated Flood Management (IFM) (WMO 2009). IFM is rooted in the framework Integrated Water Resources Management (IWRM) and promotes an integrated approach to land and water resources. As such, flood management is no longer a purely remedial task but involves issues on local territorial development.

Recent local researchers, within the field of design, adopted the integrated approach to floods in Flanders (Foré et al. 2012; Nolf and De Meulder, 2013; Nolf, 2013; Putseys, 2013). Through 'research by design', they explore the re-establishment of a distinct water structure that (re)frames current urban sprawl and future urban development. These local researches on the Flemish territory frame within the emerging field of Water Urbanism that analyses the role of water in urban design and its structuring capacity (Shannon et al. 2008). The focus lies on contemporary highly-urbanised territories (e.g. Flanders) and their complex water systems which have been labelled as 'hydraulic hydrography' (Farhat 2008); an amalgamate of drainage engineering and a natural watershed. Accordingly, Water Urbanisms' proposals are an interplay of infrastructural and landscape interventions. De Block (2015) speaks of 'techno-natural' design; a merge of technological performances with natural, ecological structures.

2) Drought design

The issue of drought is not new to landscape and urban design. In other parts of the world, there are long-standing traditions in designing water supplies that may provide inspiration for the future; water tanks in Sri Lanka (Shannon and Manawadu 2007), irrigation infrastructures in the Veneto region (Fabian and Viganò, 2010) and rainwater harvesting in India (Nawre 2015). Furthermore, (the lack of) water has been addressed by Landscape Ecology, an established field of research since the beginning of the 1980's. Amongst others, Robert France has focused on the implementation of Landscape Ecology in regional design and delivered multiple drought-related concepts; wetland restoration and aquifer recharge through bio-swales (France 2002). In addition, new design concepts are being developed to tackle current droughts within varying contexts. Clouse (2014), for example, proposes artificial glaciers as new sort of landscape infrastructure for the rural Himalaya. Meanwhile, so-called 'dry gardens' offer an attractive, yet far less water consuming alternative to California's irrigated green lawns.

A design workshop on Flanders' droughts

But how to adapt the Flemish territory, where there is little tradition in drought management, to an increasing lack of water? What are key issues for drought design in a highly urbanised territory with a moderate climate? What strategies on summer droughts can be conceived for such areas? And how do these proposals align with local landscape history and current design developments?

To that extent, the University of Antwerp, together with the Institute for Agricultural and Fisheries Research (ILVO) organized a design workshop, called Shifting Climate, Reshaping Urban landscapes (SCRUL). Design workshops have been employed to explore complex spatial issues and to draft integrated design proposals; coastal safety and sea level rise in Christchurch and Groningen (Roggema 2014; Copley, Bowring and Abbott 2015), landscape enhancement in agro-industrial areas (Cox et al. 2014), the Flemish garden complex (Dewaelheyns 2014), the Brussels rural-urban fringe (Vanempten 2014) and Beijings new urban countryside (Stokman, Rabe and Ruff 2008). Similarly, design workshops were employed in recent research on 'flood design' in diverse parts of Flanders (Nolf 2013; Putseys 2013; Nolf and De Meulder 2013).

Participants of the SCRUL design workshop were encouraged to include drought issues [3]. How can the local landscape and water infrastructure be prepared for both an abundance as well as a lack of water? The organisation compiled an international and multidisciplinary group of participants that was assisted by academic researchers, international master designers and stakeholders [4]. An overview of the design process can be found in figure 1.

Water management in the Campine landscape

The SCRUL design workshop focused on the municipalities Lommel and Overpelt, part of the Campine region [*De Kempen* in Dutch]. The Campine region is situated in the north-east of Belgium, and stretches for about a hundred kilometres from the east of the City of Antwerp, along the Dutch-Belgian border. Its sandy heathlands are part of the North European plain. It lends its name from the Latin campus or Campina, the latter indicating a region of fields. The local geophysical system is characterized by sandy soils and undulating plains intersected by numerous valleys. Within these rather infertile conditions, medieval man created a specific agricultural landscape (Fig. 2); a mosaic of cultivated land, heathland and wetland (Meeus, Wijermans and Vroom 1990; Antrop 1997; Antrop 1994). The creation of cultivated land relied on sod removal [*plaggen* in Dutch]; animal bedding mixed with manure was used to enrich surrounding sandy soils. To feed their cattle, the inhabitants depended on grass production in the nearby valleys and therefore optimized local drainage by digging artificial ditches.

In the wake of failed potato harvests in the 1840s, the newly independent Belgian state sought to cultivate the Campine wasteland [*woeste gronden* in Dutch]. Therefore, the state planned to irrigate the heathland with calcareous water of the river Meuse in order to cultivate grass on the sandy heathland (Van Acker, 2008, 2014). The increased grass production was expected to boost the overall agricultural production in the Campine [5]. In the middle of the nineteenth century, the state constructed the required water infrastructures; a canal across the Belgian part of the Campine and several water-meadows along it (Fig. 3). In Lommel and Overpelt four water-meadows were installed and a new agricultural zone, Lommel Kolonie [6], was developed. The irrigation strategy soon proved to be unsuccessful; there was a shortage of irrigation water and grass production disappointed (Van Acker 2008, 2014). The Belgian state abandoned the irrigation project. Instead, it stimulated an afforestation of the heathlands. Non-native pine trees were planted to fuel the upcoming industrial activities in the south of Belgium (Maes 1997; Van Acker 2014), but also profoundly changed the local landscape and its identity.

New water and railroad infrastructure connected the peripheral region to the outer world during the 19th and early 20th century, which triggered rapid industrial and urban development (Van Acker 2008,

2014). Today, Lommel and Overpelt are part of the Campine axis [*Kempische as* in Dutch]; an infrastructure corridor that cuts straight through the Campine region and is highly urbanised. The current local landscape is exemplary for the Flemish territorial condition; neither urban nor rural, but a complex hybrid. Multiple factors have triggered a scattered pattern; a lack of planning culture, weak legislation, subsidies for private housing, infrastructural networks (De Meulder et al. 1999).

So far there are no studies on the role of modern water supply systems in creating the Flemish hybrid condition. It seems, however, that their construction made water ubiquitous. These supply systems are situated underground, apart from the water towers, and belong to the realm of engineers. Today, extraction from surface water and groundwater each provide about 40 percent of Flemish drinking water demands (SVW 2008). Furthermore, groundwater extractions at company and farm level deliver unprecedented amounts of water to agriculture and industry (Fig. 4).

Todays' drought and other challenges

The Campine region is facing multiple drought challenges including meteorological, agricultural and hydrological drought. Recent weather events are cautionary signs of the upcoming droughts issues. The summer of 2015 highlighted the manifold impacts of an increasing lack of water. Throughout 2015 rainfall deficits were systematically accumulated, which resulted in extremely low river discharges and groundwater levels during the summer (VMM 2015). Newspapers reported how the dry weather threatened agriculture and general water supplies Flanders (Fig. 5). In addition, inland navigation is under pressure; from 2009 until 2013 draught limitations had to be temporarily introduced twice within the watershed of the Nete (VMM 2016: 95). The participants worked in small groups on three specific case studies, each confronted with one or more drought challenges.

These diverse water problems are, however, intertwined with a wide range of other spatial challenges and tendencies; sprawling urbanization, loss of farmland, pressure by tourism and recreation, landscape decay (Fig.6). As such, the region Lommel-Overpelt is a good sample of the key issues in peri-urban areas.

A first case study is the Dommel valley, a narrow strip of open space that separates Neerpelt and Overpelt. The rain fed Dommel river is characterized by a high fluctuation of water levels, which is expected to aggravate due to climate change. As such the question rises how its' valley can accommodate both floods and droughts? Large parts of the valley are, however, residential expansion areas under high urban pressure; a new school, additional housing and a park will be built in the near future. In addition, there are plans to develop a light rail connection to Hasselt on the former railroad that borders to the Dommel valley.

The second case study focusses on the valley of the Eindergatloop and the adjacent heathland. The open area separates the residential area Lommel to the west and the industrial park Nolimpark to the east. These different areas have little or no connection and water is ubiquitous thanks to numerous groundwater pumps and a vast modern water distribution network. So how do we adopt local land uses and their water infrastructure to the increasing lack of water? Meanwhile, both Lommel and Nolimpark are increasingly densified; a number of open parcels await further development. The

centrally located open area, however, experiences another kind of urban pressure. Agricultural activities make way for 'urban' land uses such as gardens, horse pastures and recreational areas.

A closer look on Lommel Colony, the third case study, reveals a certain ecological illogicality. The water meadows –*and their associated water demand*– are currently maintained as a nature reserve. Meanwhile, former marshes have been drained to create agricultural fields. Can these land uses be maintained in the future or do we need to revise the landscape? The heritage value of the landscape is, however, particularly high. In contrast, the landscape of the adjacent holiday resort Vossemeren, the village and the agricultural area is increasingly banal.

One design workshop, four design strategies

Within the multiple proposals of the SCRUL workshop, four distinct strategies dealing with drought can be discerned: 'remodelling the valleys', 'retrofitting urbanisation', 'aqueducts 2.0' and 'autonomous, local water networks'. To clarify, this list of drought strategies is not exhaustive, but merely a summary of the SCRUL workshop. The strategies differ on three aspects; (a) the natural water processes that are addressed, (b) the anthropogenic water systems that are included and (c) the landscape type of focus (see fig. 7). Each of the four drought strategies defines a redevelopment of one or more water systems in order to adapt to aggravating droughts. The following paragraphs describe the premise of each strategy; how does it prepare the territory for increasing lacks of water? In addition, the strategy's approach to the local landscape and urban tissue and its potential to transform it are discussed.

1) Remodelling the Campine valleys

A first set of designs proposes to remodel the local valleys. Although the participants were encouraged to take up the drought challenge, these participants kept an explicit focus on the most urgent and immanent water issue, being the flood management in the valleys. The underlying premise of this strategy is that flooding events offer opportunities to store water in the valley to use later, during the dry periods. As aggravating droughts require extra water, they propose to increase the buffering capacity of the valleys.

The strategy 'Remodelling the Campine valleys' aligns directly with current developments in the design discipline. The designs within this strategy propose to (re)sculpt the valley in order to restore the natural buffering capacity of the valley. To that extent, the designs apply methods from the Water Urbanism roster such as re-naturalization of watercourses and remodelling riverbeds. As previously indicated by Nolf and de Meulder (Nolf and De Meulder 2013) the local topography –*even the smallest height differences*– is a key element for such design approach. In the SCRUL proposal 'Urban WaterLandscape', for example, the topography of the valley of the Eindergatloop is tweaked in order to create a 'floodscape'; a composition of the consecutive patches with varying flood frequencies (see fig.8). Low-lying parcels are excavated in order to flood frequently, other parcels remain elevated and flood only rarely. The (re-)creation of wet conditions allows for extra water to be stored in the valley during flooding events in order to use it during dry periods.

Furthermore, these designs were confronted with a challenging paradox; how to (re)create natural flood plains in a valley that is highly urbanized and subjected to ongoing urban sprawl? In response, the designs propose a multitude of flood resistant land uses. In the proposal 'Water XL, Flooding for

Nature', for example, the valley of the Dommel is redeveloped into a green-blue corridor. The corridor consists of a sequence of natural and man-made open floodable spaces; a wetland park (inspired by the Minghu park of Turenscape), a natural floodplain that serves as a lounging beach, and a more mineral, floodable town square (inspired by the Water Squares of De Urbanisten).

2) *Retrofitting urbanisation*

A second strategy that can be demarcated is 'retrofitting urbanisation'. Today much rainwater and wastewater is immediately drained by an extensive sewage system. This 'hydraulic hydrography' (Farhat, 2008) is disconnected from and constitutes a threat to the natural hydrography. In Lommel the sewage system collects all rainwater run-off and conducts it directly to a remote water treatment plant. This artificial drainage reduces the natural recharge of the local phreatic aquifer, which supplies the adjacent watercourse Eindergatloop with water. As such, ongoing seal surfacing in Lommel, and the associated loss of rainwater infiltration, will dry-out the Eindergatloop. To that end, Flemish policy work attempts to limit seal surfacing through planning regulations. The 'retrofitting urbanization' strategy, however, remodels the urban drainage.

The design 'Urban rivers 2.0' proposes to redesign the streetscape and its currently subterranean sewage network (see fig.9). Various parts of the streets are de-paved in order to integrate elongated water infiltration ponds and bio swales. The participants refer to the projects Rain Gardens in Portland and Jardin Niel in Toulouse, among others. The new ponds and swales allow for rainwater run-off to infiltrate and to resupply the aquifers, instead of draining rainwater in concrete underground pipes to the local water treatment plant. Moreover, these interventions form a fine-meshed set of planted water channels that conduct rainwater to the nearby valley during storm events, when soils are quickly saturated and water can no longer infiltrate. In the valley, that has been adequately shaped to buffer water, the influx of water is stored in order to reuse it later on.

The strategy makes use of current developments in urban drainage. In Flanders, and elsewhere, the sewage system is being de-duplicated; one separate system is reserved for wastewater, another for rainwater run-off (or so-called grey water). As such, the strategy partly pairs up with established policy and current efforts. Yet, this design radically opposes the current technocratic sewage system. Today, the design and management of sewage is the domain of a distinct administration and highly specialized engineers. This SCRUL design, however, locates the new drainage network above-ground; moving it from the realm of the engineer to the realm of the designer. The strategy aligns with Bélanger's proposition to (re)configure the urban ecological flows through re-design of the landscape infrastructure (Bélanger 2013). In this case, a new green-blue network, that crisscrosses the urban tissue, recuperates rainwater run-off that otherwise would have been drained immediately.

3) *Aqueducts 2.0*

A third drought strategy, 'Aqueducts 2.0', is closely linked to the Urban Metabolism framework, which conceptualizes the city as a flow of materials and energy (Broto, Allen and Rapoport 2012). The designs map the wide variety of local water users who consume various types of water; premium drinking water for housing, cooling and rinse water for industry, groundwater for agricultural irrigation and rain-water feeding the natural wetlands. The strategy 'Aqueducts 2.0' rethinks the current singular use of water and re-interpret every water consumer as a water producer. The local sewage treatment plant, for example, is not seen as an outlet but a source of purified water. Thus, the strategy somewhat

aligns with the work of P-REX studio that searches for systemic changes in large-scale design (Berger 2009).

The designs propose to (re)match (urban) supply and (rural) water demands by enrolling an additional layer of water infrastructure. In the proposal 'La Route d'Eau' (see fig.10), for example, the liveability of the agricultural landscape is secured by rainwater run-off and rinse water of the adjacent housing and industrial area. This water is stored and cleaned in a landscape of interconnected ecological reed ponds, which is integrated into the public space of Lommel and Nolimpark. These ponds supply agriculture with water for livestock production, aquaponics and horticultural irrigation.

The added infrastructure is no underground pipeline, but a modern retake on the classical aqueduct. The designs propose to integrate the additional water network within the impending development of a new light-rail. The designs elevate the tracks, thus creating a modern via- and aqueduct. Just as other 'technical' urban infrastructures (Hauck, Keller and Kleinekort 2011), the new aqueduct is an object of landscape and architectural design, and not purely hydraulic engineering. How does the aqueduct, for example, interact with the landscape? Moreover, what functions may find shelter underneath the structure? In the agricultural area, for example, the aqueduct can host either biking paths and farmers' markets or high-tech aquaponics and large-scale stables (see fig.11).

4) Autonomous, local water networks

The fourth strategy, 'autonomous, local water networks', applies a similar perspective to the drought issue. The designs (re)connect different land uses *-each simultaneously a user and supplier of water-* in order to optimize local water flows. In contrast to 'Aqueducts 2.0', however, water is redistributed locally. Inspired by its history as an experiment on agricultural autarky (see [4]), the designs strive for a water autonomous Lommel Colony; the area is cut off from existing, large-scale networks. Local networks are developed as an alternative to water supply by the canal and drainage by the sewage.

The strategy fits in with the growing call for closed cycles on a local scale. In this case, the rainwater run-off and sewage of the housing area is purified by nature in order to be re-used either as drinking water or irrigation water. Similar closed water cycles have been proposed in different contexts; the small town of Talavera de la Reina (Carl Steinitz' studio on the Tajo river), Casablanca (SMAQ) and the megatropolis Istanbul (51N4E and H+N+S). Like these projects, the proposed alternative networks for Lommel Colony are techno-natural; they comprise both landscape (e.g. reed plantations) as well as technical (e.g. redirection of underground pipelines) interventions.

The development of such water cycles is used to revise the local landscape. The SCRUL designs differ on this aspect. In the proposal 'Pilot project 2050', the new water cycle is employed to reinforce the scenic value and the landscape heritage. The proposal tweaks existing infrastructures and landscape relicts. The historical water meadows, for example, are given a contemporary, ecological function (see fig.12). The channels are planted with reed in order to clean the sewage of Lommel Colony, before it is re-used to irrigate the nearby agricultural fields.

The design 'From colony to collectivity', however, redesigns the monotonous living condition of the suburban housing tissue (see fig.13). The design argues that current suburbia, which consists solely of single family housing with private gardens, is too expensive and too unsustainable to be maintained. In particular, the proposal questions the typical 'green lawns', which are fundamentally unsustainable in the Campine region as they demand regular irrigation. The designers illustrate the added value of

collective spaces. Collective gardens, urban agriculture and multi-family housing are inserted in the generic housing tissue. In these new spaces water is reused a multitude of times. For example, urban sewage water is cleaned by new patches of reed, situated in the collective gardens, and re-used to irrigate the new community gardens.

Discussion and conclusions

The design workshop 'Shifting Climate, Reshaping Urban Landscapes' delivered a non-exhaustive list of design strategies to adapt the Campine region to the challenge of emerging drought. These strategies are no ready-made solutions but demand further research by design. Nevertheless, together the proposals highlight key issues of drought design in urbanised territories: (a) the integration of different water systems, (b) an interdisciplinary approach and (c) the inclusion of local socio-economic challenges.

Firstly, the SCRUL strategies addressed and intertwined multiple water systems; the local watercourse, the subsoil water flows, the drainage of rainwater run-off, the urban sewage, the water supply system. Today, each of these systems are designed and managed separately. The SCRUL strategies illustrated the potential of an integrated approach through urban and landscape design, thus suggesting to broaden the 'water scope'. Urban and landscape design must acknowledge the (re)development of all water systems, not just the local natural watercourses. Within current water design, there is, however, surprisingly little knowledge on today's *-hidden-* water networks (e.g. underground sewage and water distribution) at hand. Further design on drought demands, however, a sound understanding of quantity and quality issues in all local water systems. Therefore, we argue that the current highly-specialised knowledge on sewage and water supplies should be (further) unlocked to urban and landscape designers.

Secondly, the SCRUL workshop delivered primarily techno-natural designs. The proposed strategies (re)connect natural with engineered water systems through an interplay of soft and hard interventions. As such, the integrated strategies break with disciplinary schisms between landscape architecture, urban design, hydraulic engineering and other disciplines. Likewise, they go beyond the existing dichotomy 'urban versus rural' and use the peri-urban condition to its advantage, e.g. housing delivers water to agriculture. Accordingly, the SCRUL workshop endorses the call for an interdisciplinary approach to highly urbanised territories, combining interventions such as buffer basins with water purifying reed ponds or light rail and bicycle tracks on top of water (re)distribution networks.

Thirdly, the SCRUL strategies were focused on, but not limited to drought issues. The proposals address various non-climate challenges; ecological connectivity, increased biodiversity, revitalisation of public space, landscape heritage. From its drought perspective, the proposals intervene in multiple ways upon the highly urbanised territory. To some extent, the water strategies frame current and future urban sprawl in order to protect strategic open spaces from further urbanisation, e.g. the open valley of the Dommel. On the other hand, the strategies apply a pro-active approach by developing a landscape infrastructure that adapts the territory to droughts. To that extent, the open space is actively reshaped in order to accommodate water buffering or to enable water infiltration. Likewise, the proposals adjust the urban tissue, e.g. by opening up sealed street surfaces to allow for infiltration. It is clear that there is an inextricable link between drought design and a regions' socio-economic/spatial development, which determines future water demand and supply. As such, drought is no stand-alone

challenge but must be incorporated in an overall vision on the region. Consequently, we suggest that further research should focus on the integration of drought management and local development through landscape and urban design.

Endnotes

[1] Climate adaptation is the process that seeks to reduce the (negative) impacts of climate change, both first-order impacts (e.g. floods) as well as second-order impacts (e.g. changing agricultural productivity). Climate adaptation comprises both unplanned and planned actions.

[2] To clarify, there is some policy work on water demand, mostly broad campaigns on sparing use of water and regulations on pumping of groundwater. At watershed scale, however, area-specific drought policies are lacking.

[3] Participants were given data on local climate effects and first-order impacts; changing weather variability, aggravating floods and droughts. Detailed data on local second-order impacts was not available.

[4] Twenty-four international design students, from eight different countries, participated in the SCRUL workshop. The educational background of these participants was diverse; landscape architecture (11), urban design (8), spatial planning and others (5). Three international master designers visited the design workshop and assisted the participants in their design process. These master designers were Henri Bava (Agence Ter), Florian Boer (De Urbanisten) and Cees van der Veeke (Lola landscape architects).

[5] The construction of water-meadows would allow for grass production to feed cattle. The cattle in turn would provide manure to fertilize the heathlands and to facilitate arable farming.

[6] Lommel Kolonie was an agricultural experiment of the Belgian state. Twenty farms were created upon the infertile heathlands. The new farmer were asked to cultivate a patch of heathland (arable farming) and a parcel in the adjacent water-meadows (grass cultivation).

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FIGURES

FIGURE 1

Figure 1: Overview of the SCRUL design process

FIGURE 2

Figure 2: The traditional landscape of Lommel and Overpelt consisted of a mosaic of cultivated land (beige), heathland (white) and wetlands (green).

(left: Degault, 1786, *Kaart van het grensgebied tussen de Verenigde Provincies en de Oostenrijkse Nederlanden*, Rijksarchief Brussel, adapted by authors)

(right: Ferraris, 1771-1778, *Kabinetskaart der Oostenrijkse Nederlanden en het Prinsbisdom Luik*, Rijksarchief Brussel, adapted by authors)

(historical photos by vzw Erfgoed Lommel)

FIGURE 3

Figure 3: Around 1850, the engineer Kümmer dug a canal to bring in calcareous water from the Meuse river. Along the canal, he constructed water-meadows (green) to produce grass and founded new farms (beige) on the heathland.

(left: Carte Militaire, 1848-1853, Carte des Environs du Camp de Beverloo, Rijksarchief Brussel, adapted by authors)

(historical photos by vzw Erfgoed Lommel)

FIGURE 4

Figure 4: Today, the structuring role of soils and water conditions is lost. Groundwater extraction and fertilisation, for example, made agricultural production on former heathland possible. Meanwhile, groundwater is extracted along the canal to supply the area with drinking water. (beige = agricultural land use, green = grassland)

(Federale Overheidsdienst Financiën, 2012, *Cadmap*, Kadastrale toestand 2012, adapted by the authors)

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(Vlaamse Milieumaatschappij, 2004, *Beschermingszones van grondwaterwinningen*, toestand September 2004, adapted by the authors)

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Beschermingszones van grondwaterwinningen, toestand September 2004

FIGURE 5

Figure 5: Drought-related headlines during 2015

FIGURE 6

Figure 6: Three case studies within the municipalities Lommel and Overpelt.

(Federale Overheidsdienst Financiën, 2012, *Cadmap*, Kadastrale toestand 2012, adapted by the authors)

FIGURE 7

Figure 7: (left) Overview of natural processes, the area of focus and anthropogenic water systems

(right) Diagram summarizing the focus of each strategy

FIGURE 8

Figure 8: (left) The valley of the Eindergatloop is currently a composition of grassland (green), arable land (beige/brown) and horse pastures and gardens (yellow and orange).

(right) The proposal Urban Waterscape tweaks the topography in order to create a 'floodscape'. Retention ponds and floodable areas are added to the valley, which is reserved for grassland, horse pastures and gardens.

(graphical material by the authors)

FIGURE 9

Figure 9: A new network of bio swales and infiltration ponds are integrated in the streetscapes of Lommel and collect rain-water run-off. Lateral braches conduct the collected water to the adjacent valley, where it is used by agriculture.

(graphical material by the authors)

(reference photos; Rain Gardens, Portland)

FIGURE 10

Figure 10: The aqueduct 'La Route d'Eau' spans over an agricultural valley and supplies water for irrigation. The aqueduct is nourished by the adjacent urban and industrial zones, where water is collected and cleaned in ponds.

(graphical material by Amr Faress, Jasmien Smets and Nadine Wagstaff)

FIGURE 11

Figure 11: Underneath the aqueduct 'La Route d'Eau' various functions may find shelter; a bike rental shop, a farmers market, a greenhouse.

(graphical material by Amr Faress, Jasmien Smets and Nadine Wagstaff)

FIGURE 12

Figure 12: 'Pilot Project 2050' re-uses the water-meadows to clean the sewage of the adjacent housing.

The purified water is used to irrigate the agricultural zone.

(graphical material by the authors)

FIGURE 13

Figure 13: The project 'From colony to collectivity' adds communal spaces to the housing area and constructs green-blue networks in the agricultural zone. In this way, water can be stored and reused locally.

(graphical material by Jolein Bergers, Nourhan Ashraf Abdelmonem and Samuel Van de Vijver)