

# A BETTER WATER FUTURE FOR FLANDERS

---

## *A Thinking Exercise in Flanders*

### *KVAB Thinkers in residence programme 2016*

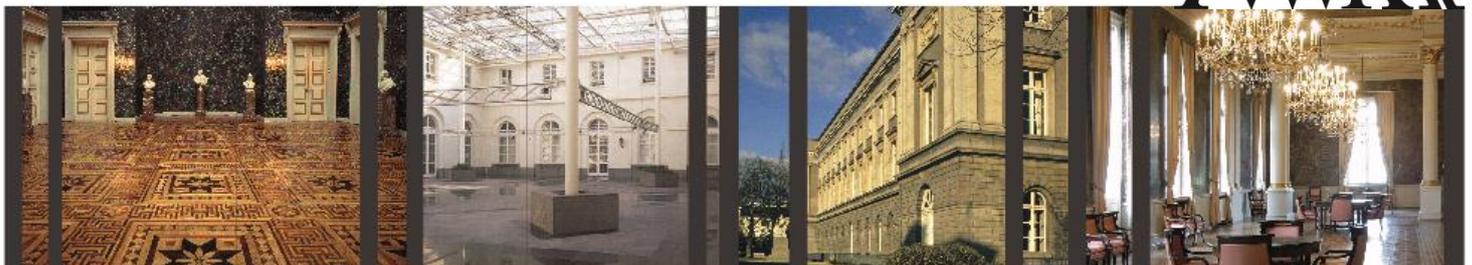
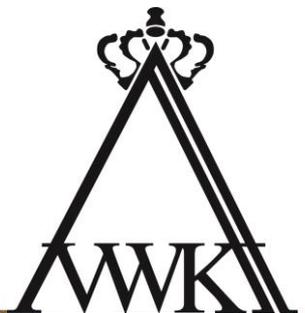
Margaret Catley-Carlson<sup>1</sup>

Glen T. Daigger, Ph.D., P.E., BCEE, NAE<sup>2</sup>

Caroline van Steendam<sup>3</sup>

<sup>1</sup> UN Secretary General Advisory Board on Water; Canadian Water Network Vancouver, BC, Canada, <sup>2</sup> Professor of Engineering Practice, Department of Civil and Environmental Engineering, University of Michigan, USA, <sup>3</sup> Ph.D. Candidate, Department of Civil and Environmental Engineering, University of Michigan, USA

Koninklijke Vlaamse Academie van België voor Wetenschappen en Kunsten  
Paleis der Academiën – Hertogsstraat 1 – 1000 Brussel – België  
info@kvab.be – www.kvab.be



# A BETTER WATER FUTURE FOR FLANDERS – “NOT TOO MUCH, NOT TOO LITTLE”

## TABLE OF CONTENTS

1	INTRODUCTION .....	3
1.1	The Royal Flemish Academy of Belgium for Science and Arts 2016 Thinkers Programme .....	3
1.2	2015-2016 Thinkers Programme .....	3
1.3	Methodology .....	3
2	IS FLANDERS WATER-SAFE, OR IS “TOO MUCH” WATER INEVITABLE? .....	4
2.1	Urban and Peri-Urban Flooding.....	4
2.2	Coastal and River Defenses.....	5
3	IS FLANDERS WATER-SECURE: CAN SUFFICIENT WATER BE MADE AVAILABLE FOR DESIRED USES? .....	6
4	ARE FLANDERS WATER RESOURCES SUFFICIENT? .....	9
4.1	Physical resources .....	9
4.2	Human Resources .....	9
4.3	New Financial Resource Needs .....	10
4.4	Governance Resources .....	10
5	FINDINGS AND RECOMMENDATIONS .....	10
5.1	Findings .....	10
5.2	Recommendations .....	11
6	ACKNOWLEDGEMENTS.....	12
7	DOCUMENTS REVIEWED AND REFERENCES .....	12

# 1 INTRODUCTION

## 1.1 The Royal Flemish Academy of Belgium for Science and Arts 2016 Thinkers Programme

The Royal Flemish Academy of Belgium for Science and the Arts (The Royal Flemish Academy) receives financial resources from the Flemish Government to invite 1 or 2 highly regarded scholars, called 'thinkers', to come to Flanders at several occasions over the period of about a year. The scholars are introduced to the specifics of a particular topic in Flanders via the members of a task force, appointed by the Academy. They are given the opportunity to discuss with important opinion makers, politicians, university professors, industrial managers, and other types of stakeholders, as appropriate. The thinkers construct their specific appraisal /evaluation of the situation in Flanders concerning the selected theme /topic of concern over this timeframe. They have the full freedom to draft a set of recommendations, actions, confrontations, as they see fit. The year is closed by a one-day symposium at the Royal Academy in Brussels. The overall quintessence of their 'experience' is consolidated in a short document, and should provide guidance for the Flemish Government.

## 1.2 2015-2016 Thinkers Programme

The theme selected by the Academy for the 2015-2016 Thinkers Programme is: RESILIENT PATHWAYS FOR TACKLING WATER & CLIMATE CHALLENGES (VEERKRACHTIGE PADEN VOOR DE AANPAK VAN WATER & KLIMAAT UITDAGINGEN). Two parts were proposed to be developed in parallel:

- **Governance with respect to the cluster of Water/Climate Change/Resilience.** There is a problem of serious overuse of groundwater in Flanders by society and industry. There is also a very long lasting problem of poor water quality in terms of nitrate, particularly due to intensive agriculture. However, there are also very intriguing cases of best practices, such as the recycling of wastewater to drinking water in Oostduinkerke (the first case in Europe). Margaret Catley-Carson was selected as one of the two "water thinkers" particularly to address these issues.
- **Technological potential in the context of Water/Climate Change/Resilience.** Flanders has to face various problems in terms of flooding, development of technology for resource recovery, designing new water services, and planning of cities for the future. Glen Daigger was selected as one of the two "water thinkers" particularly to address these issues.

Caroline van Steendam, a Ph.D. candidate at the University of Michigan but also a Belgian citizen, was further enlisted as "associate thinker". Brief biographical sketches of the three thinkers are attached below.

## 1.3 Methodology

Two one-week-long visits provided the opportunity for the thinkers to interact as described above. The first visit occurred October 26-30, 2015, and the second March 7-11, 2016. A complete list of meetings and activities during these two visits, and those who attended the meetings, is attached. A concluding symposium was held in Brussels June 17, 2016. This report documents the outcomes of the programme and the findings and recommendations of the thinkers.

In response to our charge, we have **not** herein described Flanders' water resources, governance structure or current players or regulations; these are well described in many quality studies. We have

concentrated on needed change as perceived through hours of dialogue with dozens of helpful and informative interlocutors, and on how, given the current structures and processes, such changes can be made. To accomplish this, we sought to answer the following questions:

1. Can Flanders be more water-safe against coastal erosion and urban flooding, from coastal and river fronts? What short- and long-term measures are needed?
2. Can Flanders be made more water-secure for people's health and livelihoods and national economic prosperity: those water needs in agriculture, industry, transport, environment, and potable use? What immediate and long-term measures are needed?
3. Are Flanders' resources adequate to meet the challenges to provide such a water-safe and water-secure region: physical, human, governance, and financial resources?
4. How can these measures be aggregated into a do-able strategy for improvement now, and for laying the basis for substantial medium-term change?

The following sections address these four questions, including our assessment and needed actions, with the fourth question addressed in our **Findings and Recommendations**.

## 2 IS FLANDERS WATER-SAFE, OR IS “TOO MUCH” WATER INEVITABLE?

### 2.1 Urban and Peri-Urban Flooding

The current and anticipated future situation appears to be well characterized. Precipitation patterns are changing, and extreme weather conditions are becoming more frequent (VMM, 2014b). For example, the annual precipitation increased by 0.55 mm/year (with a total increase of 94 mm from 1833 to 2014, see Figure 1.a), while the number of days with heavy precipitation doubled since the 1950s (Figure 1.b). Past spatial planning practices (or the lack hereof) have resulted in construction in locations vulnerable to flooding. These practices also adversely impact modern water management approaches by, e.g., denying implementation of the “room for the river” approach. Water safety of the people and economy of Flanders are subject to real threats. The combination of dense urbanization and intensified rainfall in Flanders leads to more numerous and severe floods. 7,000 homes are subject to flooding which, together with major storms, will cause property and land damage as the coasts and river inlets experience increasing storm and weather events. The average annual damage associated with floods in Flanders currently already exceeds 50 million euros (VMM, 2015d).

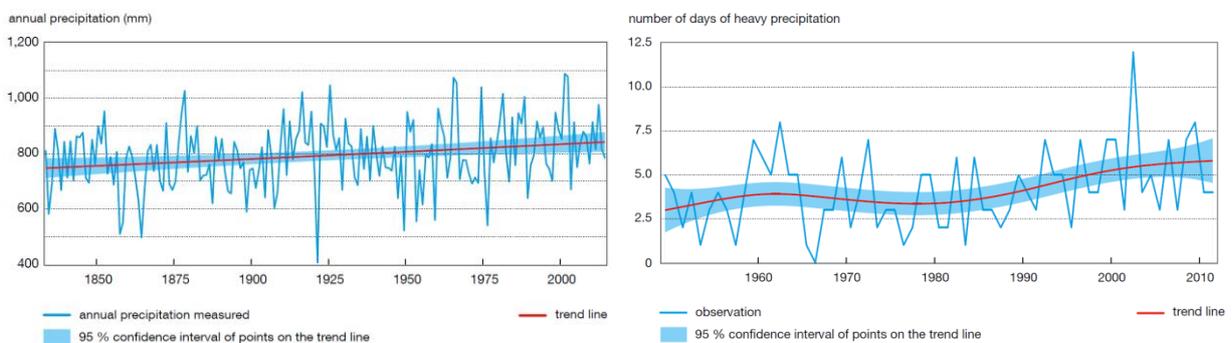


Figure 1: (a) The evolution of annual precipitation in Uccle (1833 – 2014), (b) Number of days of heavy precipitation ( $\leq 20.0$  mm per day) in Uccle (1951 – 2013). Source: (VMM, 2015c).

There are very good human and science resources devoted to urban flood forecasting and modelling (e.g., the Flanders Environment Agency or VMM). Governments have taken coordinated action at several levels to forestall the expansion of flooding. There is agreement on procedures to designate flood prone zones and advisories against construction. There is also general compliance with the EU Framework Directive on Flooding. There is agreement on a 30+ year plan which would make the 2050 risk level the same as the one in 2010.

Although the current and future situation is well characterized, actions are needed to implement the necessary responses. It is difficult, if not impossible, to make changes in public policy if the media, social communication, and general public are not aware of the issues, what is being done about them, *and what needs to be done*. The general public is, to a large extent, unaware of measures taken by public authorities, and of the element of personal responsibility involved. Moreover, in some instances there appears to be a fair element of 'capture' by which interest groups can elongate the public consultation process to indefinitely postpone measures needed to create environmental improvement. A major increased investment in a **professionally managed communication campaign** should be undertaken to **improve** understanding of why policies exist, and of personal and household responsibility, vis à vis urban flooding: housing design, location etc. The tone should be optimistic that property damage and inconvenience can be minimized with common effort. The recent campaign about multilayered water security in Flanders organized by the Integrated Water Policy in Flanders (CIW) and the corresponding video 'Hoog water zonder kater' is a good example of this.

The Government should affirm the current policy intention to meet increasing flood challenges with continued public investments at a level necessary to keep **risk at the current levels** or lower. It should be repeated that all taxpayers will be paying these costs, which will increase, depending in good part on whether all home and building owners comply with flood regulations. Holding this strategy will entail continuous costs but will avoid sudden and major cost increases, explaining why a budget needs to be laid out for the next 40 years.

Once the communication campaign is running, the Government should give public notice of an **intention to convert the current construction advice regarding building in flood plains (promulgated by CIW) to a binding proscription**. There will need to be consultations with the different orders of government which have responsibilities in this area. Some compensation or offset financing may be needed, which should be weighed against the amounts the Government is paying when flooding does occur. The date of this taking effect might also have to be negotiated.

The Government should request a trusted individual to **review the procedures for public hearings** for environmental projects and to determine whether some reshaping is necessary to prevent non-involved parties from stalling actions.

## 2.2 Coastal and River Defenses

Actions are already being taken to address the potential impacts of climate change on some components of the water cycle. The risk for flooding is further increased by sea-level rise at the Belgian coast (Figure 2), i.e., 115 mm in Oostende (1951 – 2013), 81 mm in Nieuwpoort (1967 – 2013), and 42 mm in Zeebrugge (1979 – 2013), as 15% of the land surface in Flanders is less than 5 meters above the average sea level (VMM, 2015c). A plan to address coastal flooding up to a 1,000-year storm incorporates provisions to address expected climate change through the year 2050 or 2100 (as appropriate for the specific components), and initial efforts are underway to develop further defenses (K. Van den Berghe et al., 2014; Agentschap Maritieme Dienstverlening en Kust et al., 2014). Flanders has world-acknowledged private sector capabilities in this area, and their expertise should be brought into the analytical task. A successful, although slow and expensive, project in the Scheldt river has buttressed water defenses of Antwerp and surrounding areas.

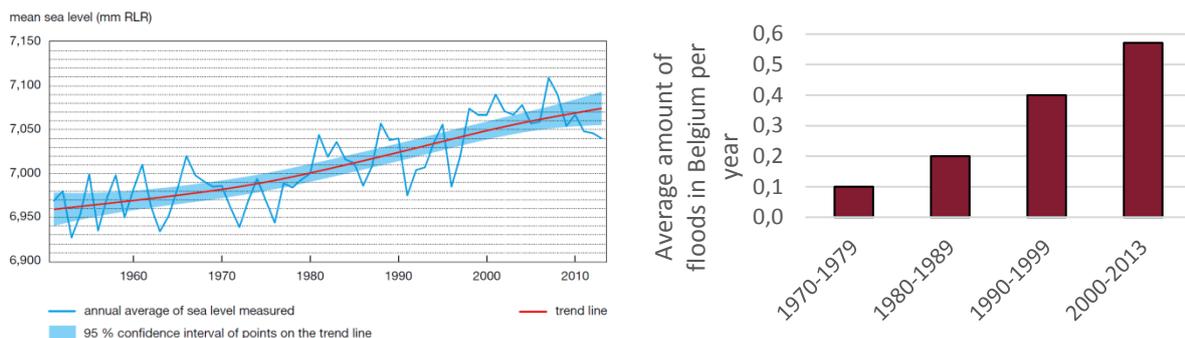


Figure 2: (left) Evolution of the mean sea level at the Belgian coast (Oostende, 1951 – 2013) (VMM, 2015c). (right) The average amount of floods in Belgium per year (VMM, 2014a).

Short and long term action is needed on coastal/river water safety:

- While a Coastal Defense plan exists and has been in implementation for some time, the **lack of public awareness** on options, current response, and risks needs to be remedied in the aforementioned communication work. An understanding of how 'building with nature', as opposed to dikes and dams, is being adopted around the world and should be included. The success of the Sigma project should be included in this effort.
- A **Multi Party Working Group** should be established with political representatives from as many parties as possible to inform all parties of the pros and cons of several possible approaches to protection, costs, domestic capabilities, and potential changes in order that the future government coalitions and their plans are well informed on this issue of vital importance to Flanders, and prepared to assume the financial costs associated with action.

### 3 IS FLANDERS WATER-SECURE: CAN SUFFICIENT WATER BE MADE AVAILABLE FOR DESIRED USES?

While Flanders possesses sufficient water resources (see below), these must be used wisely because high population density creates the potential for restricted water availability. Climate change will exacerbate this, as it is estimated that the severe droughts, such as that experienced in 1976, may become the norm in the future (H. Tabari et al., 2015a, 2015b). The significant impact of water availability on the Flemish economy is indicated by the fact that the number of employees working in the top 15% of industries, and consuming the largest volumes of water, account for 16.7% of all employees in Flanders. In other words, 1 out of 6 jobs in Flanders is directly interlinked with water (Vlakwa, 2013). Important industrial sectors are highly dependent on a reliable and robust water supply, including important chemical and food process industries and agriculture, and water-based transport of industrial goods is widely used.

Several elements of change are needed quite urgently to increase Flanders' water security. Economy and jobs are menaced by the serious drawdown of groundwater in some (but not all) areas, which, firstly, brings forth the need for stricter regulation involving minimizing drawdown as well as maximizing recharge. A report from the Rekenhof (a collateral institution of the parliament) shows that the water level in 14 out of 42 groundwater reservoirs in Flanders did not meet the European Framework Directive guidelines (2000/60/EG) in 2014 (Rekenhof, 2014). Secondly, the (sometimes related) real dangers of water shortage should be brought into focus and given resources and attention now. Thirdly, water-reuse regulations should be broadened and assess the required water-quality for a certain application, instead of the water-source (fit for purpose water quality standards). Even though Flanders announced (to the European Commission) intentions to spend € 60 million on grey-water projects, only about € 5 million was allocated to such projects by 2014. Only two out of

nine proposed projects were selected, which further illustrates the need for a broadening of regulation (Rekenhof, 2014). Utilities and operators are competent but could do more with more policy space and less strictures which decrease initiative and profit opportunities. Finally, agreements with neighboring source countries should be considered.

Water quality is also compromised by past practices. Recent (i.e., 2014) data collected in accordance with the European Union Water Framework Directive indicate that none of the water bodies in Flanders are in 'good status', mainly due to a substandard biological and hydromorphological quality (VMM, 2014c). 80% do not comply with the requirements for macro-invertebrates, macrophytes, and phytobenthos, while only 12% are in 'good' or 'very good' hydromorphological status. More than 50% of groundwater bodies are reported to have poor chemical status (EEA, 2015). Agriculture is dominantly responsible for the high nutrient concentrations observed (i.e., for 61% of emitted nitrogen and 44% of emitted phosphorus (VMM (2015a)). Due to the large surplus of nitrogen in agricultural soils (118 kg of nitrogen per hectare of land, corresponding to the 5<sup>th</sup> largest surplus of all member countries of the organization of economic co-operation and development (OECD) as shown in Figure 3 (OECD, 2015), the annual diffuse agricultural nitrogen emissions approach 100 kg per hectare of land area (EEA, 2010). Discharge of domestic wastewater was responsible for 73% of the biochemical and 44% of the chemical oxygen demand concentrations in surface waters in 2014 (VMM, 2015a). Substantial progress has been made in wastewater treatment as, while only one third of the domestic wastewater was actually treated in 1991 (Aquafin), it was substantially higher for most Flemish communities in 2014 (VMM, 2015b), averaging to, e.g., 73.3% in 2008 (VMM, 2013).

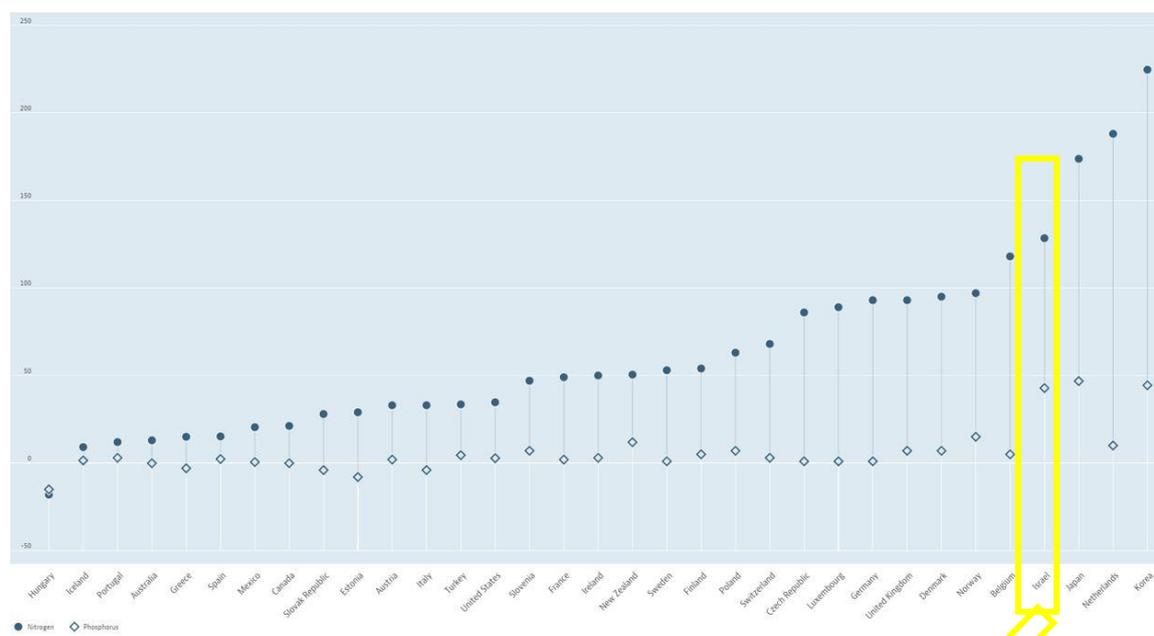


Figure 3: Nutrient surplus for all OECD countries, calculated as the difference between the nutrient inputs entering a farming system (mainly livestock manure and fertilizers) and the nutrient outputs leaving the system (the uptake of nutrients for crop and pasture production). Source: OECD (2015).

The following actions are suggested:

- **Water shortage must be monitored.** Shortage can be serious to a large part of the economy, even if it does not reach the level of a formal declaration of a state of drought. Shortage, which can be regional or sectoral (for example for transport in a canal or river), is not seen as a major monitored issue in water management, possibly because the last serious full drought was 40 years ago. However, current estimates suggest that the severe water shortage experienced in 1976 could become the future norm with the expected temperature rises. The adverse economic consequences for

Flanders would be severe if this situation were to develop and justifies significant actions and investments to prevent it.

- Senior officials (e.g., CIW) should be charged (and financially enabled) to create analogous high quality data now existing for groundwater monitoring provided by VMM towards the purpose of flood modelling. There is a need to predict and warn water shortages.
- Serious and sustained programmes should be initiated in **groundwater areas where drawdown consistently exceeds uptake** (although not all aquifers are in this situation). Remedy should be sought for areas with groundwater deficits, in collaboration with utilities and industrial and agricultural users. Tailored solutions will be needed for individual situations. Aquifer storage and recovery, which is a common practice in many locations outside of Flanders, should be implemented where appropriate, along with restrictions on withdrawals to match recharge rates.
- A **national workshop on water re-use for all purposes** should be convened, and should take advantage of international expertise on groundwater re-charge.
- The Government should prepare for periods of shortage through prior decision on **restrictions and priorities for water availability** in times and areas of shortage, as is done in neighboring countries. The CIW in the first instance would appear to have the capabilities to suggest a schedule for Ministerial attention.
- The Government should build on the positive and far seeing regulation which requires new houses and buildings to have rainwater harvesting facilities, and that these are used for indoor flushing. Why not **a campaign to extend this practice to existing houses and buildings in areas that experience water shortage**? Similarly, the public can be informed about and encouraged to pay a great deal more attention to infiltration.
- Flanders can stop missing out on important new developments in wastewater treatment such as energy saving and resource extraction.
  - o Water, and the products which can be extracted from it, can be an essential component of the circular economy. While initial efforts to develop the components of such a system, such as the recovery of energy, phosphorus, and other materials, are being investigated, including initial pilots and demonstrations, barriers appear to exist to the broader integration of these components into the Flanders economy. The Government should commission a trusted individual or group to prepare a concise statement of the degree to which re-use of water and materials is permitted in the EU, and the current practices of a sample of EU member states. To the extent that EU regulations are constraining desirable practice, Flanders should make common cause with others for change.
  - o OVAM offers an example of a high performing organization and entrepreneurial civil service for waste management to sustainable materials management. This example should be emulated for wastewater treatment, establishing performance standards and monitoring arrangements and allowing a more entrepreneurial approach to emerge.
- The two major rivers in Flanders are transboundary from both a Federal and international perspective. While some agreements exist to resolve transboundary water issues and water availability, others are lacking, for example concerning the Meuse which originates in France. This compromises important components of Flanders' water supply.

## 4 ARE FLANDERS WATER RESOURCES SUFFICIENT?

Water resources include not only physical resources, but human, financial, and governance resources.

### 4.1 Physical resources

While Flanders is a humid climate with abundant rainfall, it is also densely populated which results in a relatively low water resource per capita, as illustrated in Figure 4 (VMM, 2013). These further result in water challenges which are unique compared to other Northern European countries. Moreover, the two major rivers in Flanders are transboundary from both a Federal and international perspective. While some agreements exist to resolve transboundary water issues and water availability, others are lacking, for example concerning the Meuse which originates in France. Ground water is plentiful in some areas, declining in others; well managed in some places, less in others.

While this situation poses challenges for Flanders, proven approaches are readily available to address them. Numerous developed and prosperous societies around the world face significantly greater challenges than does Flanders but have applied a variety of approaches to achieve water security; Israel and Singapore representing two prime examples. These include water efficiency, rainwater harvesting, water reclamation and reuse, and seawater desalination. Thus, the available physical resources do not prevent Flanders from achieving a water-secure future.

### 4.2 Human Resources

Flanders possesses an abundance of intellectual and professional resources for addressing the full range of water issues. These include well-known and highly capable university programs, a competent professional community, and capable professional organizations such as water utilities, government research organizations, and commercial enterprises. There are excellent long-term reports on virtually all of the issues covered in this paper.

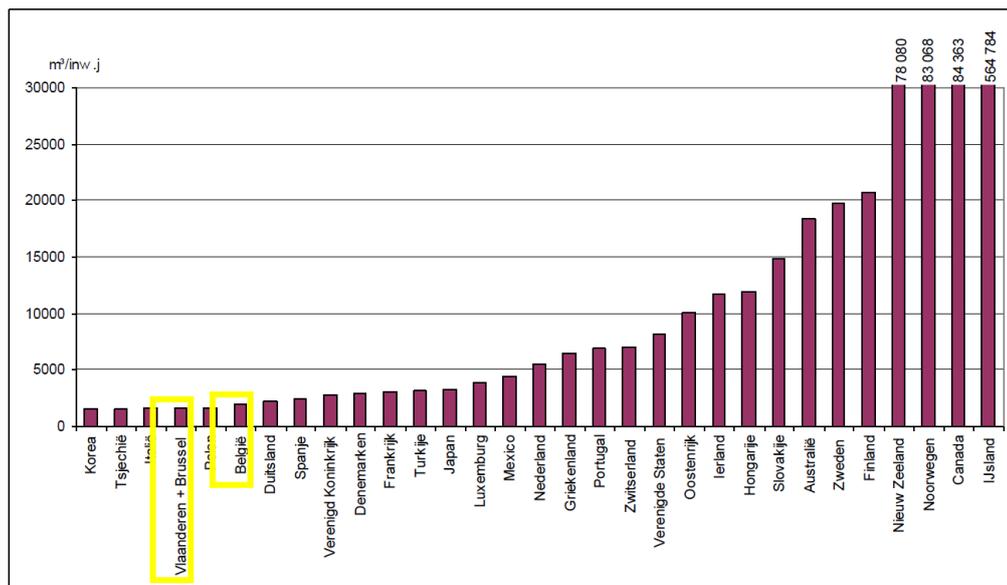


Figure 4: Water availability in the OECD countries. Source: (VMM, 2013).

The CIW is providing an important coordinating function between the various ministries and agencies responsible for various components of the Flanders water system.

### **4.3 New Financial Resource Needs**

This Report calls for additional resources for communication, for monitoring water shortages, and perhaps for financial incentives to move the 'advisory' notices on construction to 'prescriptive'. Some expenditure is needed now to establish the he suggested long-term political level work on coastal resources options. The infrastructure expenditures decided upon will be very costly, but with potential for shared expenditure and energy revenue which can be included in future decisions on major resources for coastal defenses and further river work.

**The most important resource being sought is public time and attention on water management.**

### **4.4 Governance Resources**

The general public does not appear to appreciate the essential role water plays in the Flanders economy (OECD, 2011), in spite of the relative water scarcity which exists. This occurs, apparently, because water appears to the general public to be relatively available, and domestic water service is reliable.

There are many instances of more than adequate governance and management: the water utilities, etc., but the existing governance structure in Flanders is complex, includes many actors, and provides numerous opportunities for local self-interest to over-ride actions which can be of broader benefit. Some elements of this are not unusual in a democracy, but the general success of various water management measures vary. It appears that this issue exists to a certain extent due to incomplete understanding of program approaches and objectives, and of the actual status of specific projects. This unequal and incomplete understanding of objectives and status is an important barrier to developing consensus on the actual situation in Flanders and the most desirable path forward.

## **5 FINDINGS AND RECOMMENDATIONS**

### **5.1 Findings**

In summary, we find that Flanders possesses the necessary resources to secure a water-safe and water-secure future for its citizens. It possesses the physical, human, and financial resources to do so. Past approaches and practices must evolve, however, as Flanders is faced with a growing population, evolving economy and social structure, and climate change, as is every other region. The necessary changes to secure a water-safe and water-secure future are well within reach for Flanders, but the decision to make these changes must be taken and acted on.

We also find that, while the potential negative effects of climate change on water supply are quantified, few if any actions are apparent to prepare for and mitigate them. Flanders is acting to address the mandates of the European Union Water Framework Directive (WFD) and Flood Directive (FD). Progress on addressing flooding is apparent (as identified above), but Flanders' waterways largely do not comply with the objectives of the WFD. While progress is being made in the control of pollutant mass loadings from point sources (municipal and industrial), little progress is apparent from non-point sources, particularly agriculture. Thus, actions are necessary to secure a water-safe and

water-secure-future. The suggestions of the Thinkers, some of which have already been introduced above, are listed below.

## 5.2 Recommendations

### An immediate set of actions to be implemented now:

- Begin a **communication campaign** on Flanders Water Management, focused on challenges and roles to be played. Message should be "light" but purposeful (e.g., 'Hoog water zonder kater'). It should be designed to raise the level of awareness of the essential nature of water to the Flanders economy, to develop public support for change, and to encourage individual and household behavior consistent with flood protection and water harvesting objectives.
- Establish a **monitoring and early warning system for water shortages** (using existing data and the flood models and by reinforcing VMM personnel).
- Decide and announce what level of government will make decisions on water **allocations and water restrictions in times of shortage**.
- Establish an industry/government/utilities short term high level **Task Force to recommend changes now in order to replenish acquirers and groundwater**, drawing on the best existing models of international practice. Begin with shortage-prone areas.
- Announce a **campaign to encourage rooftop rainwater capture for external water use** (and a subsidy program for piping the water indoors for, e.g., toilet use).
- **For Coastal flooding response establish an all-party exercise** to inform on the prospects and potential remedial measures. The next Government should have as a priority the establishment of budget, and this should be discussed in a manner which shares available information and best practice as widely as possible across the political spectrum.
- Assemble the human and financial resources to begin work on a **Flanders Water Management Strategy**, to be carried forward in the next Plan (see immediately below).

### A commitment now, backed by action, to lay a better foundation for future water management in Flanders:

These short-term actions should be coupled with the development of a commitment in principle to develop a **consensus vision for water in Flanders**, along with an **action plan for achieving it**. We call for development of a **Flanders Water Management Plan**, focused on ensuring a reliable, robust, and resilient water supply, coupled with protection against flooding. Midterm preparatory action would include budgetary provisions, and an agenda for development of the Plan. Action on **water governance** must be an **integral part of such a plan** and such an exercise. Consensus by all that we talked to was that the situation in Flanders significantly restricts available options and slows actions which appear to be quite beneficial. The attempt to get permission for action was described to us as 'nightmarish', and many interlocutors were of the strong view that the current situation in its complexity and overlapping nature, with so many levels, was a great deterrent to initiative and change. Not only is a plan needed, but it must be implemented. In essence we are recommending an on-going process, with development of the plan as only one component. Essential actions in support of this process include:

- A **consensus vision for water in Flanders**, along with an **action plan for achieving it**, must be developed. This vision and plan should build on the foundation provided by the existing human capital and institutional and physical infrastructure, but provide the basis for a secure water future for Flanders. The method to develop this vision, and the plan to achieve it, will require some level of institutional reform and agreement on institutional parties. The CIW is a logical institution to provide essential components to achieve this, but consideration should be given to other approaches as well.

- An **integrated approach** to increase the **resilience of the water supply system to water shortages and flooding** is needed. Important steps have been taken in this direction through the aggregation of formerly competing Departments into a single Ministry and Minister, and through the work done by CIW. Current vulnerabilities exist, however, and will only become more severe in response to population and economic growth and climate change.
- **Budgetary and plan provision** must be made now, and included in **broad based and effective communication**. Communication is needed to provide access to relevant information and to engage stakeholders and actors in the decision and implementation process. Communication with the general public is also necessary
- **Actions** necessary to implement such a plan must be **firmly anchored in government actions**, including **commitment of the necessary long-term funding**, going forward. It must be anchored in a manner which transcends multiple governments, as full realization of the steps necessary to ensure a safe and secure water future for Flanders will take considerable time. Consistent actions will be required over time, with focus on the social benefits that will result, rather than simply consideration of the cost.
- Finally, action on **water governance** must be an **integral part of such a plan** and such an exercise. The current situation in Flanders, which significantly restricts available options and slows actions which appear to be quite beneficial, must be addressed and resolved.

## 6 ACKNOWLEDGEMENTS

The three of us would like to thank the Royal Flemish Academy of Belgium for Science and the Arts (The Royal Flemish Academy) for inviting us to serve as Thinkers. We hope that we have contributed something to improved water management in Flanders to at least partially compensate for what we have learned. Moreover, the hospitality and openness to discussions shown by all has been truly extraordinary. We thank the Royal Flemish Academy for the excellent arrangements consistently provided. While there are too many to thank explicitly, we especially need to recognize Inez Dua of the Royal Flemish Academy for taking such good care of us, and Professor Willy Verstraete for inviting us.

## 7 DOCUMENTS REVIEWED AND REFERENCES

- Aquafin. (2015). Infrastructuur en omgeving. Retrieved 28 November 2015
- K. Van den Berghe, & R. De Sutter. (2014). The governance dilemma in the Flanders coastal region between integrated water managers and spatial planners. *Water international*, 39(6), 858-871. doi: 10.1080/02508060.2014.954663
- EEA. (2010). The European environment state and outlook: Freshwater quality.
- EEA. (2015). News highlight: More than half of EU surface waters below 'good' ecological status.
- Agentschap Maritieme Dienstverlening en Kust, Afdeling Kust, & Waterbouwkunding Laboratium. (2014). Masterplan Kustveiligheid.
- OECD. (2011). Water Governance in OECD Countries: A Multi-level Approach *OECD Studies on Water*.
- OECD. (2015). Nutrient balance (indicator). Retrieved 28 November, 2015, from <https://data.oecd.org/agrland/nutrient-balance.htm>
- Rekenhof. (2014). Bescherming en herstel van de grondwatervoorraden. *Verslag van het Rekenhof aan het Vlaams Parlement*.
- H. Tabari, M.T. Taye, & P. Willems. (2015a). Actualisatie en verfijning klimaatscenario's tot 2100 voor Vlaanderen – Nieuwe modelprojecties voor Ukkel op basis van globale klimaatmodellen (CMIP5).

*Study commissioned by the Operational Water Management unit of the Flanders Environment Agency and MIRA, available at [www.milieurapport.be](http://www.milieurapport.be), by KU Leuven – Department of Hydraulics.*

H. Tabari, M.T. Taye, & P. Willems. (2015b). Water availability change in central Belgium for the late 21st century. *Global and Planetary Change*.

Vlakwa. (2013). The socio-economic importance of water in Flanders - Summary.

VMM. (2013). MIRA - Themabeschrijving: Waterkwantiteit.

VMM. (2014a). Aantal overstromingen per decennium. Retrieved 12/03, 2015, from <http://www.milieurapport.be/nl/feitencijfers/milieuthemas/waterkwantiteit/overstromingen/aantal-overstromingen-per-decennium/>

VMM. (2014b). MIRA: Future outlook report 2014.

VMM. (2014c). Nieuwe meetresultaten oppervlaktewaterkwaliteit. Retrieved 29 November, 2015, from <https://www.vmm.be/nieuws/archief/nieuwe-meetresultaten-oppervlaktewaterkwaliteit>

VMM. (2015a). Bronnen van waterverontreiniging in 2014.

VMM. (2015b). Evaluatie saneringsinfrastructuur 2014.

VMM. (2015c). MIRA: Climate report 2015.

VMM. (2015d, November 2015). MIRA: Overstromingsrisico. Retrieved 12/3, 2015, from <http://www.milieurapport.be/nl/feitencijfers/milieuthemas/waterkwantiteit/overstromingen/overstromingsrisico/>

## THE THINKERS

**Margaret Catley-Carlson** operates within Boards of Organizations focused on improved water resource management and agricultural productivity and rural development, serving with 20+ in the last decades. Now PAC Chair of the International Commission on Integrated Mountain Development (ICIMOD), Vice Chair Canadian Water Network Board, member Syngenta Foundation for Sustainable Development, International Fertilizer Development Council, International Food Policy Research Institute (IFPRI). She is a Patron/ past Chair Global Water Partnership, member of the Council of Advisors of the World Food Prize, Library of Alexandria in Egypt, and the Robert Daugherty Institute on Water for Food production. Jurist of the Tyler and Stockholm Water Prizes; President Canadian International Development Agency 1983-89; Deputy Executive Director UNICEF New York 1981-1983; President Population Council New York 1993-98; Deputy Minister Health and Welfare Canada 1989-92. Ms. Catley-Carlson has ten honorary degrees and is an Officer of the Order of Canada

**Glen T. Daigger, Ph.D., P.E., BCEE, NAE** is currently Professor of Engineering Practice at the University of Michigan and President and Founder of One Water Solutions, LLC, a water engineering and innovation firm. He previously served as Senior Vice President and Chief Technology Officer for CH2M HILL where he was employed for 35 years, as well as Professor and Chair of Environmental Systems Engineering at Clemson University. Actively engaged in the water profession through major projects, and as author or co-author of more than 100 technical papers, four books, and several technical manuals, he contributes to significantly advance practice within the water profession. Deeply involved in professional activities, he is currently Immediate Past President of the International Water Association (IWA). The recipient of numerous awards, including the Kappe, Freese, and Feng lectures and the Harrison Prescott Eddy, Morgan, and the Gascoigne Awards, he is a Distinguished Member of the American Society of Civil Engineers (ASCE), a Distinguished Fellow of IWA, and a Fellow of the Water Environment Federation (WEF). A member of a number of professional societies, Dr. Daigger is also a member of the U.S. National Academy of Engineers.

**Caroline van Steendam** is a PhD candidate, pursuing a degree in Environmental Engineering at the University of Michigan and in Chemical Engineering at the University of Leuven (KU Leuven, Belgium). Co-advised by Profs. Ilse Smets, Steven Skerlos, Lutgarde Raskin, she is spearheading a pilot-scale and bench-scale study to decrease impacts related to wastewater treatment by facilitating widespread implementation of anaerobic membrane bioreactors. To further support this endeavor, she is currently performing a life cycle assessment to identify the field in which this technology

constitutes a more sustainable option than current alternatives. She was awarded with the 'TNAV prize: Best Thesis regarding Water and Sludge Technology' for her Master's Thesis (Chemical Engineering, KU Leuven) and recently received the honor of becoming an ITiMS fellow (Integrated Training in Microbial Systems). As an officer for GrEENPEAS (a departmental organization aspiring to bring students and faculty closer together) and the outreach-officer for the Society of Women in Engineering (SWE) at the University of Michigan, she organizes many educational and engaging events for students of all ages.