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Water management in the military: The SmartBlue Camp Profiling Tool

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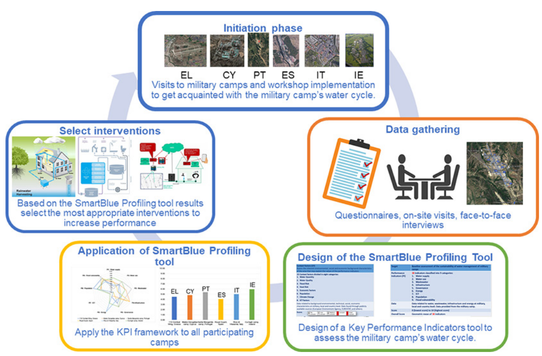
HIGHLIGHTS

- Development of an assessment framework for military camps' water management
- Application to six military camps in six different EU countries
- Usability of the framework to identify potential water management interventions

GRAPHICAL ABSTRACT



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ABSTRACT

Increasingly, military installations are becoming part of the ongoing discussion on environmental sustainability. Military installations, and camps in particular, often resemble small towns in terms of inhabitants and demand for resources, but are significantly different from civilian settings in terms of autonomy needs, resource management, population make up and operational requirements. In this context, what is missing is the development of a specialised and standardised framework able to assess the status of military camps in terms of water resources management and infrastructures' sustainability. To this end, we develop and present the SmartBlue Camp profiling tool. The tool comprises of 31 Performance Indicators (PI) that evaluate the sustainability of water management in a camp, covering all aspects of the "military water cycle", and 15 Context Factors (CF) that assess background characteristics of the surrounding area, enabling a deeper understanding and interpretation of PI values. We also present the implementation of the tool in six European military camps, identifying priorities and opportunities for performance improvement and short-listing specific technological interventions at a case by case basis, able to address water challenges at the camp level.

1. Introduction

Water infrastructure in Europe is facing pressures due to climatic changes and lack of significant investments that would allow for adaptation to new demand and supply patterns (OECD, 2015) prompting an interest in emerging concepts like resilience (Makropoulos et al., 2018). At the same time, sustainability of water management in cities worldwide has already gained significant attention, as attested by the International Water Association's (IWA) report in 2016 which presented six main indicator frameworks that aim to assess water management in cities (IWA, 2016). Out of these frameworks some have been applied worldwide and some are more locally focused. An example of a framework that has already been globally applied is the City Blueprint ® framework (Van Leeuwen et al., 2012, 2016), which has already been applied in at least 60 municipalities and regions in 30 countries worldwide. Another

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key framework is the Water Governance in Cities (OECD, 2016) framework, developed by the Organisation for Economic Cooperation and Development (OECD) to track and measure relevant water governance variables in view of the OECD Principles on Water Governance.[1] This has already been applied in 48 cities in OECD and non-OECD countries.

In this ongoing discussion however, military installations are one of the least acknowledged parameters in both distributed water management and pollution control despite their ubiquitous presence. These installations often have significant water demands, sometimes relying on groundwater abstraction from depleted groundwater aquifers, and are arguably a potential source of diffused pollution, through drainage and wastewater disposal.

Military camps are essentially small-to-medium towns, with inhabitants, living and working across a significant area. They are, by nature, dispersed throughout the countryside and hence not necessarily connected to centralized water infrastructure (such as water distribution networks, drainage systems and wastewater treatment plants (WWTP)). Infrastructure is often old with significant part of the users being transient populations, which inevitably limits the 'sense of ownership' and separates (water demand) behaviour from personal impact in terms of costs. On the other hand, military installations possess a number of unique properties that could turn what can be initially seen as a problem, into a best practice demonstration:

- Space availability in military installations allows for the deployment of novel distributed water management practices, including, Sustainable Drainage Systems (SUDS), grey and black water reuse, green roofs and rainwater harvesting.
- The existence of personnel, able to be trained to undertake maintenance tasks for these distributed practices, can bypass a common barrier for adoption of these technologies: that of poor maintenance and long-term ownership.
- Transferability of best practices, once tested, is guaranteed by the similarity of the characteristics of military installations, personnel training and adoption of routine procedures.
- The long-term commitment of the military to best practices, once tested, is less sensitive to changing trends, policies and economic issues that often affect other stakeholders (e.g. local authorities)

The modern European Army is increasingly aware of the importance of environmental protection and climate change adaptation and as such it is currently launching a number of initiatives to address environmental protection issues within its boundaries (EDA, 2016). This work presents the findings of one such project, the Smart Blue Water Camps (SBWC) project, which aimed to assess the sustainability of water resources management and infrastructure of six (6) European military camps and to propose technological interventions to improve water management at the camp level where appropriate. The following sections present the Key Performance Indicator framework that was developed for this purpose and its application to six (6) European military camps.

2. Material and methods

The development of the SmartBlue Camp profiling tool was initially based on the rationale of the City Blueprint ® framework which is designed to support strategic planning of integrated water management at the city level (Van Leeuwen et al., 2012, 2016). The final version of the proposed framework, adjusted for (yet not constrained to) the military sector, is the result of several revisions performed after feedback received through a series of 6 workshops organised together with experts from the military and environmental sector to support knowledge transfer of the "military water cycle" and the identification of specificities of military camps. The framework aims not only to enable the quick understanding of water management conditions in the assessed camps but also to allow comparisons and identification of opportunities for change (need to decrease water supply, opportunities to increase water reuse, requirements for renovation, gaps in personnel allocation for water management etc.).

The SmartBlue Camp profiling tool consists of two distinct sets of indicators classified into **Context Factors (CF)** and **Performance Indicators (PI)**.

- Performance Indicators assess the sustainability of water management in the military camp, while
- Context Factors allow for an understanding and contextualisation of PI results by evaluating the background characteristics of the surrounding area.

The indicators of two categories are presented in detail in the next two sections.

2.1. Context factors

Context Factors assess the inherent environmental, social and economic background characteristics of the area where the military installations are located and explain the values of the performance indicators. Fifteen (15) context factors (CF) have been identified, divided into eight (8) categories:

CF1. Water Quantity evaluates the quantitative status of water resources in the River Basin District (RBD – as defined within the Water Framework Directive) where the military camp is situated. The calculation of this context factor requires the evaluation of:

- **Freshwater Scarcity** based on the European Environment Agency's Water Exploitation Index plus (WEI+) indicator (EEA, 2017).
- **Groundwater Scarcity** based on the European Environment Agency's Water Exploitation Index plus (WEI+) indicator but only for groundwater resources (EEA, 2017).
- **Groundwater mineralisation** qualitatively assessing the groundwater status due to natural geology and/or manmade pressures.

CF2. Water Quality evaluates the qualitative status of water resources in the RBD, where the military camp is situated, based on the results of the official assessment of the Water Framework Directive reported by EU Member Countries. The estimation of this factor takes into account both surface and groundwater quality.

- **Surface water quality** based on the WFD's identification of surface water quality status relevant to ecological and chemical characteristics. This indicator is estimated as the average percentage of surface water bodies with a good chemical and ecological status of the military camp's RBD (DG Environment, 2012, 2015).
- **Groundwater quality** based on the WFD's identification of groundwater quality status relevant to chemical characteristics. This indicator is estimated as the average percentage of groundwater bodies with a good chemical status of the military camp's RBD (DG Environment, 2012, 2015).

CF3. Flood Risk evaluates area's potential flood risk based on the reported results of the implementation of the EU Floods Directive. The area is firstly assessed on whether or not it was identified as a Flood Risk Area based on the Flood Directives Preliminary Flood Risk Assessment. If this assessment was positive, then the percentage of the area surrounding the camp that would flood under different return periods of floods is estimated (EU Flood Directive Overview of Progress, 2018).

CF4. Heat Risk evaluates area's potential heat risk based on an assessment published in the European Environment Agency that applies the methodology of Fischer and Schär (2010) to the urban centres of Europe.

[1] http://www.oecd.org/governance/oecd-principles-on-water-governance.htm.

CF5. Economic Factors evaluates the country's overall military budget availability. This indicator was introduced after several discussions with the participants of the SBWC project which identified as an overall descriptor of the available funds for water resources management to be not only the overall budget for military purposes but also the allocation for capital investment to infrastructures. Nevertheless, while available funds could assess the ability to invest in water resources management, the most important assessor would be the actual political will to assign funds for water management and infrastructure.

- **Total government expenditure** is an indicator developed during the SBWC project with the aim to assess the budget allocated to the military sector as percentage of the country's Gross Domestic Product (GDP). A lower than 1% of the GDP signifies a pressurised military sector, taking into consideration that water management and infrastructure is not a high priority for the military sector overall.
- **Deviation of budget allocation** is an indicator developed to assess the deviation of the country's budget allocation in comparison to the average allocation in all EU countries for each different budget category, to identify pressures that depend on the priorities of the military sector in the country of the military camp.
- **Country policies** is a qualitative indicator that aims to capture the political will of the country, where the military camp is situated, regarding the allocation of budget for water management and infrastructure. The development of this indicator was based on the results from the SBWC workshops where the participants explained that the allocation of budget for water and wastewater infrastructure was case specific and was not directly associated with overall funding of the military sector.

CF6. Population evaluates the pressures to the military sector due to changes in personnel and overall population. During the workshops, the population pressure was identified to have the least impact on water management and infrastructure for the military sector, nevertheless it was decided to include this category as a matter of completeness. This context factor takes into account changes in both country and camp population:

- **Country population change rate** identifies pressures relevant to the country's population. A decreasing population may indicate an extra economic pressure, while a rapidly increasing population may identify pressures in infrastructure systems and water resources.
- **Military population change rate** identifies pressures relevant to the military's population. A changing population may indicate an extra pressure in the maintenance of water and wastewater maintenance and management.

CF7. Climate Change evaluates the country's policies and aims to capture the country's level of involvement and political will in adaptation to climate change threats. During the workshops, it was identified, for completeness shake, to include not only water resources related policies but also policies relevant to the adaptation to climate change threats overall. This category examines:

- **Climate change adaptation** that assesses the existence of policies relevant to climate change adaptation based on the information provided by Member States of the European Union under the European mechanism for monitoring and reporting information relevant to climate change (Regulation (EU) No 525/2013, n.d.).
- **WFD implementation** that assesses the implementation of Water Framework Directive and the adoption of River Basin Management Plans.
- **Flood Directive implementation** that assesses the implementation of the Flood Directive and the adoption of Flood Risk Management Plans.

CF8. ICT factors evaluates qualitatively the availability and feasibility of ICT tools and services in the military camp and military sector in general.

The data used for the Context Factors assessment are related to the background environmental, technical, social, economic characteristics at local and country level. Data are found through publicly available sources (European Environment Agency, EUROSTAT, and others).

The Context Factors are assessed on a scale of 0 to 4. The lowest the score, the less the concern, and the highest the score, the more the concern, about the assessed background characteristics. The scoring scale is as follows: 0: No concern, 1: Low concern, 2: Medium Concern, 3: Concern, 4: High concern.

2.2. Performance indicators

Performance Indicators assess the efficiency, effectiveness and sustainability of the delivery of water services that result from the combination of several variables. The final Performance Indicator (PI) set consists of thirty-one (31) indicators classified into nine (9) categories. In the following paragraphs, the basic rational and the main assumptions are presented for each indicator, and the indicator equations are given in Appendix A.

PI1: water supply

The amount of water that is supplied to the military camp provides important information that allows to draw conclusions regarding:

- The amount of pressure the camp is putting on the water resources of the area as a competitor to the rest of the water needs.
- The economic pressure that water supply puts in the military camp.
- The military camp's infrastructure status by comparing water supply with water use.

The category of Water Supply aims to assess firstly, the level of water supply per person in comparison to acceptable levels of water supply and secondly, the proportion of self-supply per total supply of the military camp.

Indicator	Assessment	Assumption	Equation
1.1	Water supply per person	Requirements for military camps to meet all water demands: • 333 l/person per year is the low limit of water supply[a] • 755 l/person per year is the high limit of water supply[b]	Eq. (1)
1.2	Water supply Self-abstraction	A higher rate of self-abstraction of the military camp is preferred	Eq. (2)

[a] Sustainment with other activities (including universal unit level, medical operations, hygiene, engineering, aircraft maintenance) 253.56 lpd plus washing of military vehicles (for a camp population of 1000) 79.11 lpd (USACE, 2008).

[b] Highest water supply (Iceland, 2013) reported in OECD = 755 lpd (OECD, 2017) The reported value consists of all water supply irrespective of water use thus including industrial, agricultural etc. water demand.

PI2: water use

The amount of water that is actually used to meet the different water needs of the military camps allows to draw conclusions regarding:

- The efficiency of water demand management of the military camp.
- The allocation of water in the different water uses.

Water use per person is assessed based on its comparison with the water use per person of acceptable levels. Potable water use, irrigation water use and military operations water use are compared based on the total amount of water used in the military camp.

Indicator	Assessment	Assumption	Equation
2.1	Water use per person	Water demand for military camps are the same as the water supply limits given in indicator 1.1.	Eq. (3)
2.2	Potable water use	73% of water demand must be met using potable water and the remaining with non-potable (including laundry, military operations and other uses) (USACE, 2008).[a]	Eq. (4)
2.3	Irrigation water use	Based on irrigation strategies for moderate and severe water deficit in Mediterranean climates (Wriedt et al., 2009): • 0.171 cubic meters/square meters/per year is the minimum irrigation water • 0.724 cubic meters/square meters/per year is the maximum irrigation water	Eq. (5)
2.4	Military operations water use	Worst-case scenario: 100% coverage of military operations' water needs with potable water Best-case scenario: 0% coverage of military operations' water needs with potable water (USACE, 2008).	Eq. (6)

[a] Requirements for potable water for sustainment with other activities 243.36 lpd plus non-potable water requirement for sustainment and washing of military vehicles (for a camp population of 1000) 88.87 lpd. Therefore, allowed ratio of potable to total is 73% (USACE, 2008)

The indicators of the Water Use category are complemented with a pie chart that presents the allocation of water in the different potable water uses of the military camp.

PI3: wastewater

Wastewater management is key to the protection of water resources of the area where a military camp is situated. At the same time, treated wastewater is an alternative source for many water uses depending on the level of treatment (secondary or tertiary). Furthermore, wastewater treatment by-products may be used in agriculture.

The indicators of this category assess the coverage of wastewater treatment of the military camp, along with the proportion of wastewater from military operations that is treated in wastewater treatment units. Additionally, the indicators assess the proportion of water reused in comparison to the total water abstracted, used and treated.

Indicator	Assessment	Assumption	Equation
3.1a	Reused water vs treated and discharged	A higher rate of reused water within the military camp is preferred	Eq. (7)
3.1b	Reused water vs abstracted		Eq. (8)
3.1c	Reused water vs used		Eq. (9)
3.2	Military operations' wastewater treatment	A higher rate of wastewater associated with military operations treated is preferable.	Eq. (10)
3.3a	Secondary wastewater treatment	A higher rate of people connected to secondary WWT within the military camp is preferred	Eq. (11)
3.3b	Tertiary wastewater treatment	A higher rate of people connected to tertiary WWT within the military camp is preferred	Eq. (12)
3.4	Sewage sludge recycling		Eq. (13)

PI4: infrastructure

The status of water and wastewater infrastructures, in terms of type and age is used as criteria to assess infrastructure robustness. It supports the identification of the current condition of water and wastewater infrastructure in the camp, also highlighting opportunities for possible improvement.

The category assesses the age of networks and leakage losses, the percent of green and blue areas in comparison to the total area of the military camp and the type of the wastewater network with respect separation of wastewater and runoff.

Indicator	Assessment	Assumption	Equation
4.1	Water system leakages	A lower percentage of leakages is preferred	Eq. (14)
4.2a	Age of sewers	Newer sewers and water supply pipes within the military camp are preferred. 60 years is the maximum age of the pipes and 10 years is the minimum (Van Leeuwen et al., 2012).	Eq. (15)
4.2b	Age of water supply pipes		Eq. (16)
4.3	Storm water separation	Separated systems are preferred to reduce the environmental impact of the military camp and the pressures imposed to the surrounding water bodies	Eq. (17)
4.4	Percentage of green and blue areas	A higher percentage of green and blue areas is preferred to alleviate the effects of heat waves and increase the perviousness of the military area decreasing flooding risk and the pressures imposed to the surrounding water bodies	Eq. (18)

PI5: governance

The leadership of a military camp is (also) responsible for the implementation of actions and plans for water and wastewater management. In this category we aim to evaluate the commitment of the military camp towards sustainable water resources management by assessing relevant actions and plans. Additionally, the appointment of personnel to positions relevant to water resources management is assessed, allowing for the extraction of conclusions regarding both the dedication of the leadership and the requirements of the camp's water system.

Indicator	Assessment	Assumption	Equation
5.1	Water and wastewater action plans	A military camp needs to at least monitor the state of the water and wastewater infrastructure and maintain the infrastructure	See table bellow
5.2	Water and wastewater management personnel	Staff dedicated to water management within the military camp: • Maximum appointed staff 0.5% • Minimum appointed staff 0%[a]	Eq. (19)
Score		Indicator 5.1 qualitative assessment	
0		No information is available on this subject	
1		The camp is not taking any maintenance actions.	
2		The camp repairs infrastructure when assets become redundant.	
Start from a score of 2 and add 1 point for every additional action		Start from a score of 2 and add 1 point for every additional action. The camp has defined action plans for the maintenance of water and wastewater infrastructure. The camp has defined action plans for the refurbishment and the development of the water and wastewater infrastructure. The camp takes part in EU funded projects related to water and wastewater infrastructure. The camp has sufficient information (maps of networks, data about energy consumption, knowledge on pipes depth, diameters, metering devices, valves and manholes) regarding the state of the water and wastewater infrastructure. The camp collaborates with external bodies (universities etc.) for water and wastewater management.	

(*continued*)

Score	Indicator 5.1 qualitative assessment
	The camp accepts visitors (schools etc.) for the promotion of good practices relevant to water and wastewater. The camp implements an Environmental Management System. The camp implements internal information campaigns regarding the proper use of the water and wastewater infrastructure.

[a] Upper and lower limits are a result of the stakeholder participation workshops.

PI6: energy

Energy and water are directly linked due to energy requirements for the supply, treatment and distribution of water and the collection and treatment of wastewater. Additionally, energy and water are indirectly linked due to a correlation between large populations requesting overall high energy and water and large areas requiring an extended network for water distribution and wastewater collection. Furthermore, environmental pressures affect both energy and water demand in a similar way with requirements changing depending on weather e.g. hot weather requiring more water and energy, cold weather requiring more energy etc.

In this category, energy requirements, the use of renewables and energy recovery from wastewater treatment plants are assessed. The scope is to evaluate the energy required for water management, however since this information is generally difficult to define, total electricity consumption is often reported instead.

Indicator	Assessment	Assumption	Equation
6.1	Energy intensity	Required energy for water systems of a military camp, excluding water heating (Gerbens-Leenes, 2016): • maximum 4 kWh/m^3 of water supplied[a] • minimum 0 kWh/m^3 of water supplied	Eq. (20)
6.2	Energy recovery from WWT	A high rate of energy recovery from wastewater treatment plants is preferable for military operations	Eq. (21)
6.3	Fraction of renewable energy	A high rate of renewable energy generated is preferable for military operations	Eq. (22)

[a] In the Netherlands, hence comparable to European case studies, it was estimated that the energy for use (mainly heating), supply, disposal and energy for energy (ERE) is 14.3 MJ/m^3 of water = 3.97 $kWh/m^3 \approx 4\ kWh/m^3$ of water.

PI7: ICT

The deployment of integrated solutions for water and wastewater management in military camps require smart ICT systems for supervision and control in order to manage the proposed interventions remotely and ensure compliance with strict environmental standards.

In this category, the plausibility of the implementation of such technologies in military camps is assessed by exploring the availability of such technologies in the camp for water and wastewater management.

Indicator	Assessment	Assumption	Equation
7.1	ICT services for water management	It is preferable to use ICT services for the operation, maintenance, planning, design and monitoring of water and wastewater management infrastructure.	Qualitatively assess the use of ICT for each category on a scale of 0–10 and estimate the average value
7.2	ICT services for wastewater management		

PI8: population

This category aims to assess the effects camps population on water and wastewater resources and infrastructure. A low performance in this category signifies that emphasis on water efficiency should be given. However, it should be noted that interventions relevant to water and wastewater management are not in the position to change the performance on this category since the proportion of permanent staff, the variation of population and the population change of the military camp is intrinsically linked to the military camps operations e.g. training camp.

Indicator	Assessment	Assumption	Equation
8.1	Population change rate	Population variation in military camps[a]: • Maximum 30% • Maximum 10%	Eq. (23)
8.2	Population variation (min-max)	A lower variation is preferable	Eq. (24)
8.3	Permanent staff availability	A high rate of permanent personnel is preferable	Eq. (25)

[a] Upper and lower limits are a result of the stakeholder participation workshops.

PI9: flood vulnerability

Flood events may interrupt operations, damage infrastructure and create high costs for restoration. This category identifies the vulnerability of a camp to floods by assessing the risk of flooding by river and sea level rise as well as by reporting on the impervious vs pervious ratio of the camp.

It is worth noting, that workshop participants, even of camps within flood prone areas, were generally not aware of flood risks, which might be attributed to a lack of residual memory of flood events due to the transience of the military personnel.

Indicator	Assessment	Assumption	Equation
9.1	Camp vulnerability from river floods	A lower percentage of affected camp area is preferable	Eq. (26)
9.2	Camp vulnerability from sea level rise		Eq. (27)
9.3	Camp vulnerability from urban drainage floods	A lower percentage of impervious area is preferable	Eq. (28)

The data required for Performance Indicators assessment are supplied, in their majority, by the military camp under assessment (see Appendix B).

Many indicators adopt reasonable assumptions to define the range of feasible values (high and low limit) so as to enable comparison of the camps' values and assessment of their performance. These assumptions could be updated/reviewed when a larger sample size of assessed military camps becomes available.

The score of each category is estimated using the average score of the indicators that comprise the category. Considering that not all indicators are relevant to every camp, an effort was made to account for the non-applicability of some indicators or for the increased importance of others using "importance scores" to calculate a weighted average of the indicators used to estimate the score of the category, as seen in the following formula:

$$ScorePI_i = \sum_{j=1}^{n} Ind_j \times \frac{Imp_j}{\sum Imp_j}$$

where $ScorePI_i$ is the score of each i category, Ind_j is the score that the camp received for each indicator j of the category, Imp_j is the importance score that the indicator received from the representative of the participating camp.

The lowest score allowed for a Performance Indicator is zero (0) while the highest score is ten (10).

In the following section the application of the proposed framework to the six military camps that participated in the SBWC project is presented.

3. Application and data requirements

The SmartBlue Camp profiling tool was applied in six military camps in Europe. The camps were selected by the respective Ministries of Defence of the EU countries. The selection of the military camps was based in two distinctive criteria: the willingness of the camp's leadership to participate; and existing knowledge regarding the camp's water cycle. The camps are:

110 Combat Wing, Larissa, Greece

The 110 Combat Wing is situated near the city of Larissa in the plain of Thessaly, Greece (Latitude: 39.63, Longitude: 22.39). The land is flat at a low altitude of 70 m and at about 50 km from the sea. The climate is characterised as Mediterranean-continental with dry summers and mild, rainy winters.

The 110 Combat Wing supports several types of military aircrafts and the facilities of the camp are used for operational purposes and for the maintenance of aircrafts (i.e. cleaning). Additionally, the military camp includes administrative offices and accommodation for the personnel, for their families and for civilians.

The 110 Combat Wing is supplied with about 550,000 m^3 of water per year from the Municipal Water and Sewerage Company of Larissa (DEYAL). The total annual potable water consumption of the camp was estimated to about 120,000 m^3. 90% of the water is consumed for urban/domestic uses while the remaining 10% for operational uses. The potable water network is old with estimated leakages of about 76% of the water supplied (and billed).

Makis Giorgallas military camp, Mathiatis, Nicosia, Cyprus

The camp of Makis Giorgallas is situated 25 km W of the city of Nicosia in Cyprus (Latitude: 34.95, Longitude: 33.33). The altitude is approximately 480 m above the sea level and the camp is about 23 km away from the sea. The climate is Mediterranean with very mild winters and warm to hot summers.

The military camp has Army Land Units (Armor and Infantry), administrative services and accommodation for the personnel.

"Makis Giorgallas" camp is supplied with 63,870 m^3 of water per year from the Water Development Department of Cyprus. About 45,000 m^3 of water per year cover the total potable water demand of the camp. The remaining 20,000 m^3 are used to cover military water needs, like armed vehicles washing. The camp's infrastructure is fairly new and the adjacent military camp of "Panteli Katelari" operates a WWTP which treats all collected wastewater and provides around 1000 m^3 of treated water per year to irrigate some small gardens and parks of the camp.

Santa Margarida military camp, Costancia, Ribatejo, Portugal

The Santa Margarida military camp is situated at 130 km North-East to Lisbon (Portugal) on the left bank of Tagus River (Latitude: 39.26, Longitude: 8.17). The majority of the terrain is a Heathland habitat—a type of landscape characterised by sandy and dry soils and shrub vegetation. The climate of the area is characterised as Mediterranean with hot and dry summers and wet and moderate winters.

The facilities of the camp are used for operational purposes including firing ranges, a landing strip and several areas for tactical military manoeuvres of the mechanised divisions and for the maintenance of tanks and military vehicles. Additionally, the urban part of the military camp includes administrative offices and accommodation for the personnel and for some of their families, waste water treatment station, pump stations, pharmacy, church, cinema, swimming pool and other buildings.

The "Santa Margarida" military camp is supplied with water from both the public water system and 4 boreholes. The total supplied water is about 2,057,918 m^3 per year with 510,611 m^3 per year abstracted from the aquifer and 1,547,307 m^3 per year publicly supplied. Abstracted water is mainly used for irrigation and military operations. Additionally, water is treated and recycled locally for many military purposes. The camp operates its own wastewater treatment plant which supplies treated water to recharge the aquifer that is used by the 4 boreholes.

Prince royal guard & regiment, Prince Quarter, Madrid, Spain

The Royal Guard Quarter camp is located North-West of Madrid, Spain (Latitude: 40.52, Longitude: −3.78). The altitude is approximately 613 m above the sea level. Madrid has an inland Mediterranean climate. Winters are cool due to its altitude, including sporadic snowfalls and frequent frosts in January and February. Summers are hot, in the warmest month – July – average temperatures during the day ranging from 32 to 33 °C, with maximums commonly climbing over 35 °C during frequent heat waves. Due to Madrid's altitude and dry climate, diurnal ranges are often significant during the summer. In this camp the stables of the horses of the Royal Guard are located.

The Prince Royal Guard and Regiment camp is supplied with water by the public water system. The amount of water supplied annually is around 85,775 m^3 per year. Besides public water supply, the camp operates 1 borehole that abstracts 1824 m^3 per year. Almost 50% of the water supplied is used for irrigation purposes and horse maintenance. The camp is connected with the public sewerage system, which conveys sewage in the wastewater treatment plant.

Riva di Villasanta barracks, Cagliari, Sardinia, Italy

The Riva di Villasanta camp is located at the South-East end of Cagliari, Sardinia, Italy (Latitude: 39.20, Longitude: 9.14). The altitude is approximately 6 m above the sea level (the camp is around 600 m from the seafront). Cagliari has an island Mediterranean climate with hot, dry summers and very mild winters. The summer extreme values can be slightly over 40 °C, sometimes with very high humidity, while in winter, under special and rare conditions, the temperature drops slightly below zero. Heavy snowfalls occur on average every thirty years. The average temperature of the coldest month, January, is about 10 °C, and of the warmest month, August, about 25 °C. This camp is a military communications base.

The Riva di Villasanta camp is supplied with 66,673 m^3 per year from the public water supply system. 36% of this is lost due to extensive leakages from the 80-year-old piping system of the camp. The remaining 62% is used to cover domestic needs in either living quarters or offices. The camp is connected to the public wastewater treatment plant.

Defence forces training centre, Curragh Camp, Co Kildaire, Ireland

The Curragh is located 40 km South-West of Dublin, Ireland (Latitude: 53.15, Longitude: −6.84). The altitude is approximately 120 m above the sea level. Curragh experiences a maritime climate with cool summers, mild winters, and a lack of temperature extremes. The average maximum January temperature is 8.8 °C, while the average maximum July temperature is 20.2 °C. On average, the sunniest months are May and June, while the wettest month is October with 76 mm of rain, and the driest month is February with 46 mm. Rainfall is evenly distributed throughout the year. The region's sheltered location on the east coast makes it the driest place in Ireland, receiving only about half the rainfall of the west coast. The annual precipitation depth ranges from 683 mm to 714 mm. The main precipitation in winter is rain; however, snow showers do occur between November and March. Hail is more common than snow. The Curragh camp is a training centre and logistics base.

The Curragh is supplied with water by 2 boreholes and 1 shallow well. The amount of water abstracted annually is around 456,000 m^3 per year. The camp uses chlorination to disinfect abstracted water and manages the water's hardness before certain uses (i.e. washing of military vehicles, use in swimming pools, in some living quarters etc.). Due to the old age of the camp's infrastructure (>100 years old) the leakage losses reach about 63% of the total abstracted water. The camp is connected to the Bronstown wastewater treatment plant.

The camps participating in the SBWC project which were assessed based on the SmartBlue Camp profiling tool, present the following water cycle management characteristics:

- Major leakages due to old infrastructure, in three camps: the 110 Combat wing, Greece, the Riva di Vilasanta, Italy and the Curragh camp, Ireland, that remain unaddressed mainly due to lack of budget allocation (not lack of budget).
- Major reuse and recycle practices in the Santa Margarida camp, Portugal, which exhibits high self-supply of water from boreholes, reuse of used water for military purposes and recharge of the aquifer with treated water from the WWTP.
- Major irrigation water uses in Prince Royal Guard camp, Spain
- Treated water reuse practices in Makis Giorgallas camp, Cyprus
- Due to lack of water metering in all camps, with the exception of total water supply, camps made assumptions regarding the consumption of domestic water uses and allocated the remaining water consumption to military water uses or irrigation, depending on the internal knowledge regarding the military camp's operations.
- Budget for water management purposes, for paying water bills, and for refurbishing old or installing new infrastructure, is directly requested from respective Ministries of Defence, which depending on priorities provide funds. This is the case for all of the six camps, and in general, for all military camps of the six EU countries that participated in this study.

The above water cycle management characteristics pinpoint several differences between cities and military camps, mainly in respect to:

- Budget allocation, which is centrally decided. Contrary to cities, military camps in general are not autonomous.
- Water uses, which in general include the same water uses as a city but also different ones such as washing of military aircrafts and vehicles, and water uses for military operations.

A survey of the participating camps was held to acquire all necessary data for populating the tool with values and to assess the performance of the camps. Data sets were collected and a review was performed to identify points of clarification and missing data. Representatives from each camp were contacted to answer questions and give clarifications. Appendix B presents the data needed to apply the SmartBlue Camp profiling tool to a military camp. These data were complemented by communications with local personnel regarding the assessment of qualitative indicators. The actual data reported are not presented in this publication since they are under security restrictions due to the military nature of the installations.

As mentioned above, the military camps were asked to rank the importance of each of the indicators, in order to be able to depict the specific conditions of each camp. Representatives of the participating military camps were asked to fill an online questionnaire regarding the importance of each indicator for the assessment of the sustainability of water resources management in their camp. Fig. 1 presents the received rank for each indicator per military camp. It is worth noticing that almost all the indicators had a high importance with a few exceptions. Sewage sludge recycling and recovery of energy from the wastewater treatment were two indicators that received a low importance score, from all camps except the Portuguese and Cypriot camps that operate their own wastewater treatment. Additionally, only the Cypriot and Irish camps that are linked with a tertiary wastewater treatment plant responded that this indicator had a high importance. Finally, flood vulnerability from sea level rise was ranked with low or no importance for all the camps, mainly due to their geographic position (away from the coastline).

All data gathered from the participating military camps were used to populate the KPI framework and estimate the score of each indicator, each category and overall score at the camp level. The following section provides the results and discusses the performance of the military camps in view of the KPI framework.

4. Results

All six (6) participating camps were assessed using the SmartBlue Camp profiling tool. Fig. 2 presents the overall performance of the camps with regard to the Context Factors part of the KPI framework. From the assessment of the Context Factors it is possible to extract the

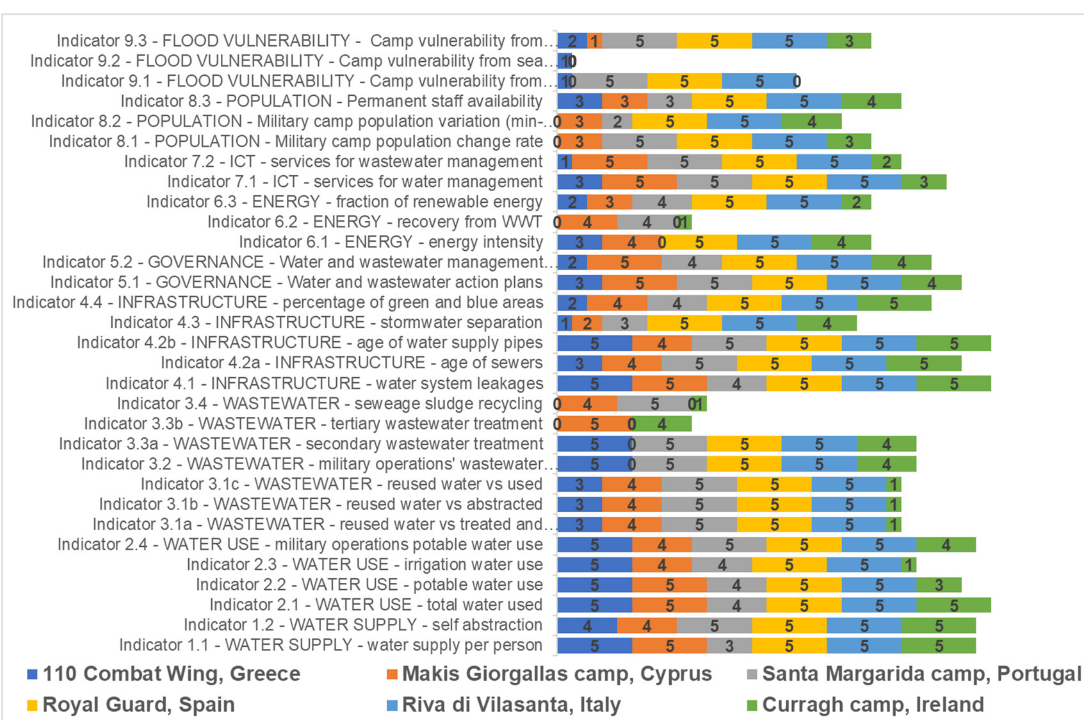

Fig. 1. Ranking of each indicator for each one of the participating military camps (Rank = 0–5 with 0 = no importance and 5 = high importance).

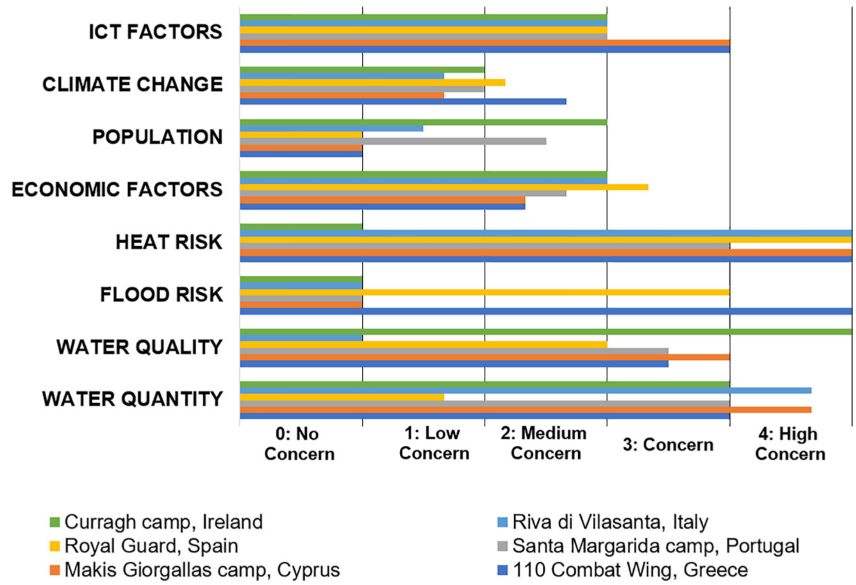

Fig. 2. Comparison of performance in the Context Factors categories of the profiling tool.

overall conclusion that environmental and climatic conditions create concerns in almost all of the camps. However, it should be noted that the participating camps are in their majority in south and Mediterranean regions, where water resources are under pressure due to the climatic conditions.

Fig. 3 presents the assessment of each camp in view of the Performance Indicators, per category. The largest the area the better the performance of a camp with respect to a given indicator. Based on the shape of the spider diagrams, presented in Fig. 3, it is possible to identify three major groups: The first group includes diagrams with an overall large area resulting in a good performance for the majority of the camps, see for example: potable water use (Diagram b – Ind2.2), irrigation water use (Diagram b - 2.3), secondary wastewater treatment (Diagram c – Ind3.3a), storm water separation (Diagram d – Ind4.3), permanent staff availability (Diagram h – Ind8.3) and flood vulnerability from sea level rise (Diagram i – Ind9.2).

The second group includes diagrams with areas of big immersions resulting in good overall performance from the majority of the camps with only some of them scoring very low, see for example: water supply per person (Diagram a – Ind1.1), water use per person (Diagram b – Ind2.1), water systems leakages (Diagram d - Ind4.1), percentage of green and blue areas (Diagram d - Ind4.4), water and wastewater management personnel (Diagram e – Ind5.2), energy intensity (Diagram f – Ind6.1), population variation (Diagram h – Ind8.2) and flood vulnerability from river floods (Diagram i – Ind9.1).

Finally, the third group includes diagrams that consist of only lines (zero area) or a very small area in comparison to the entire spider area. These diagrams depict indicators where the majority of the camps scored low, with only a few exceptions, see for example self-abstraction (Diagram a – Ind1.2), renewable energy (Diagram f – Ind6.3) and use of ICT (Diagram g) (see Fig. 3).

The ranking of indicators discussed above, is used for estimating the weighted average performance for each one of the PI categories. Using this weighted average, it is possible to arrive to an overall conclusions about the performance of each camp to the PI categories (Fig. 4). In particular, from diagram a, it is evident that the Greek and Portuguese camps have the highest per person supply and only the Irish camp is self-supplied, and as such is autonomous from the public water network. Additionally, from diagram b it is possible to identify that only the Portuguese camp has an increased per person water use. Furthermore, only the Portuguese and the Cypriot camp are reusing water (Diagram c). While the latter only uses a small quantity for watering a small garden, the Portuguese camp reuses water by treating the army vehicles' washing outflow to remove machine oil and mixing it with groundwater for reuse in the same washing facilities. Moreover, in diagram d, the issue of old and in-poor condition infrastructure is portrayed for the camps in Greece, Italy and Ireland, while old water distribution networks together with combined sewers reduce the performance of the Portuguese camp. In terms of governance (Diagram e) only the Irish and Portuguese camps perform well, due to the will of the camp's commanding officers to do more than "business-as-usual" for water and wastewater management. Additionally, the Greek camp ranks above average, mainly due to the high number of staff that are assigned to water and wastewater management. This, however, should be treated as an indication of increased needs arising from the age of the infrastructure. All camps use energy from the public network and only the Italian camp is using its barracks rooftops for solar energy, thus performing best in the Energy PI category than the rest of the camps (Diagram f). The only ICT used in the assessed military camps are radio signals that allow the monitoring of the water level in water tanks in the Portuguese and the Irish camp. All camps score above average in the Population PI category. The lower performances in this category may be attributed to the actual scope of the military camps e.g. training grounds, which suggest high variability in the population of the camp. Finally, all military camps perform well in the flood vulnerability PI category. However, it should be noted that camps participating in the SBWC project did not report any type of risk even though some of the camps were identified to be within flood risk areas. This mismatch could be attributed mainly in the fact that military camps have in their majority a high rate of pervious green areas that allow a decrease of impacts from flooding.

Fig. 5 presents the comparison between performance of the camps for the Performance indicators part of the KPI framework. From the assessment of the participating camps to the Performance Indicators, it can be seen that, overall, the camps present a low to medium performance in water supply (with values ranging from 2 to 5) and an average to high performance in water use (with values ranging from 6 to 8). The assessment pinpointed the main issue of old infrastructure and high volumes of water losses. The assessment of the camps identified a significant potential for development of ICT solutions for the management of water and wastewater infrastructure as well as a potential of reusing treated wastewater as an alternative supply of water for military operations.

Fig. 6 summarises the performance of all six (6) participating camps by introducing a metric, the SmartBlue Profile, which is the average score of the performance of the military camp to each category of the

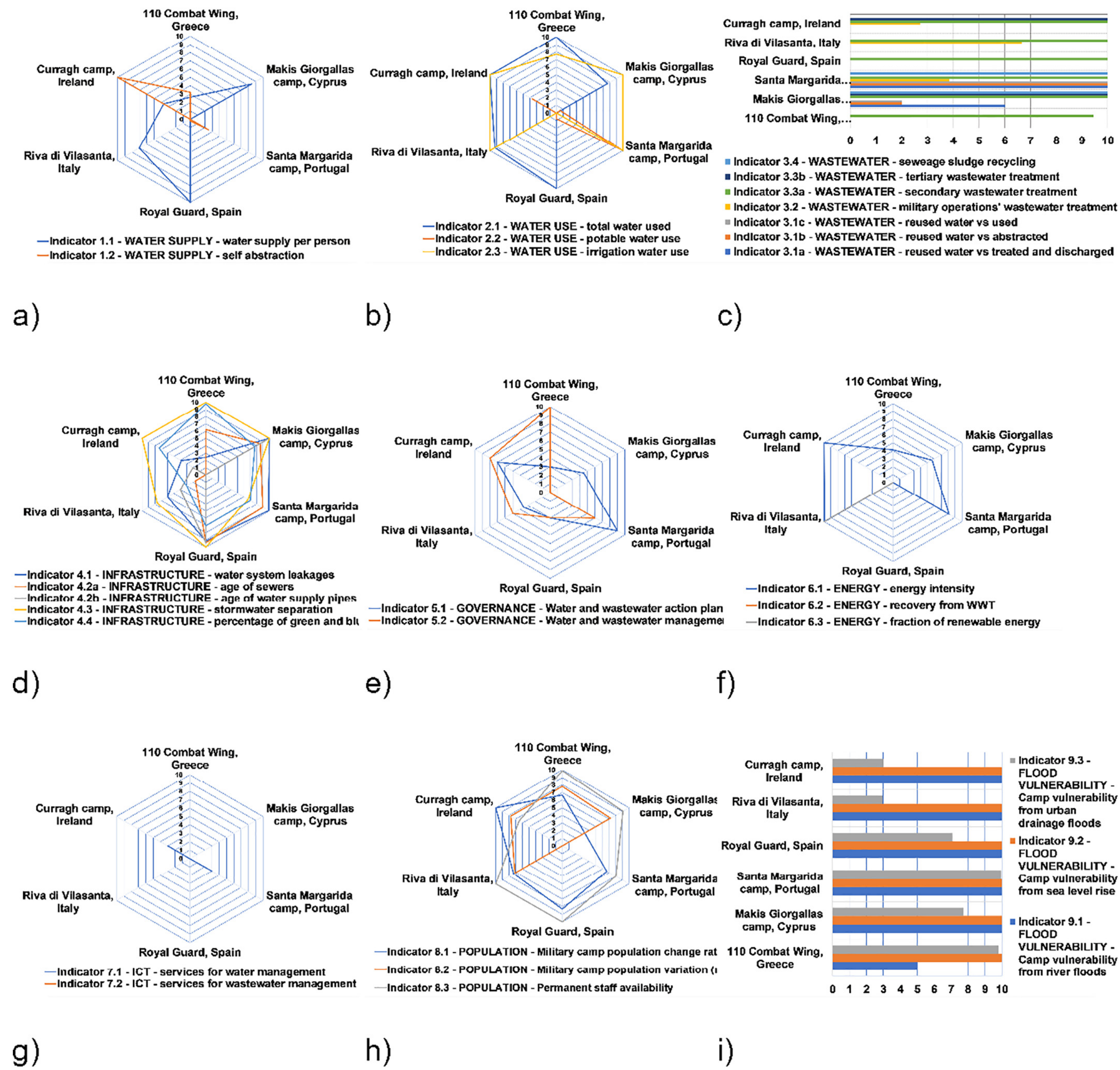

Fig. 3. Results of the assessment of each camp to the Performance Indicators of the SmartBlue Camp profiling tool.

Performance Indicators. It is possible to conclude that all of the camps have an average performance with three camps, those in Cyprus, Portugal, Italy performing a bit better and Ireland performing even higher.

In the case of Makis Giorgallas camp in Cyprus the better score can be attributed to the fact that the camp has its own wastewater treatment plant, which shares with another military camp, and the reuse of treated water. In the case of the Riva di Villasanta camp in Italy, the score can be attributed to the renewable energy production (solar panels in the barracks' roofs) and in the fact that the camp is small with mainly domestic water demands.

In the case of the Santa Margarida camp in Portugal, the score is attributed to the application of water reuse for military operations' water requirements and to a commitment to environmental and water resources management.

Finally, the Curragh camp in Ireland, has the highest score which is attributed to the autonomy of the camp in respect to water supply, the commitment to water resources management and the overall availability of data that allow a reliable assessment of the camp's performance.

5. Discussion

The selected indicators of the SmartBlue profiling tool serve a threefold purpose. Firstly, the most direct purpose, already discussed in previous sections, is to assess the camps in terms of both the characteristics of the area/country in which they are situated as well as the camp's actual performance in terms of water management.

Secondly, during the process of the assessment a key purpose has been transfer knowledge regarding the conditions affecting water

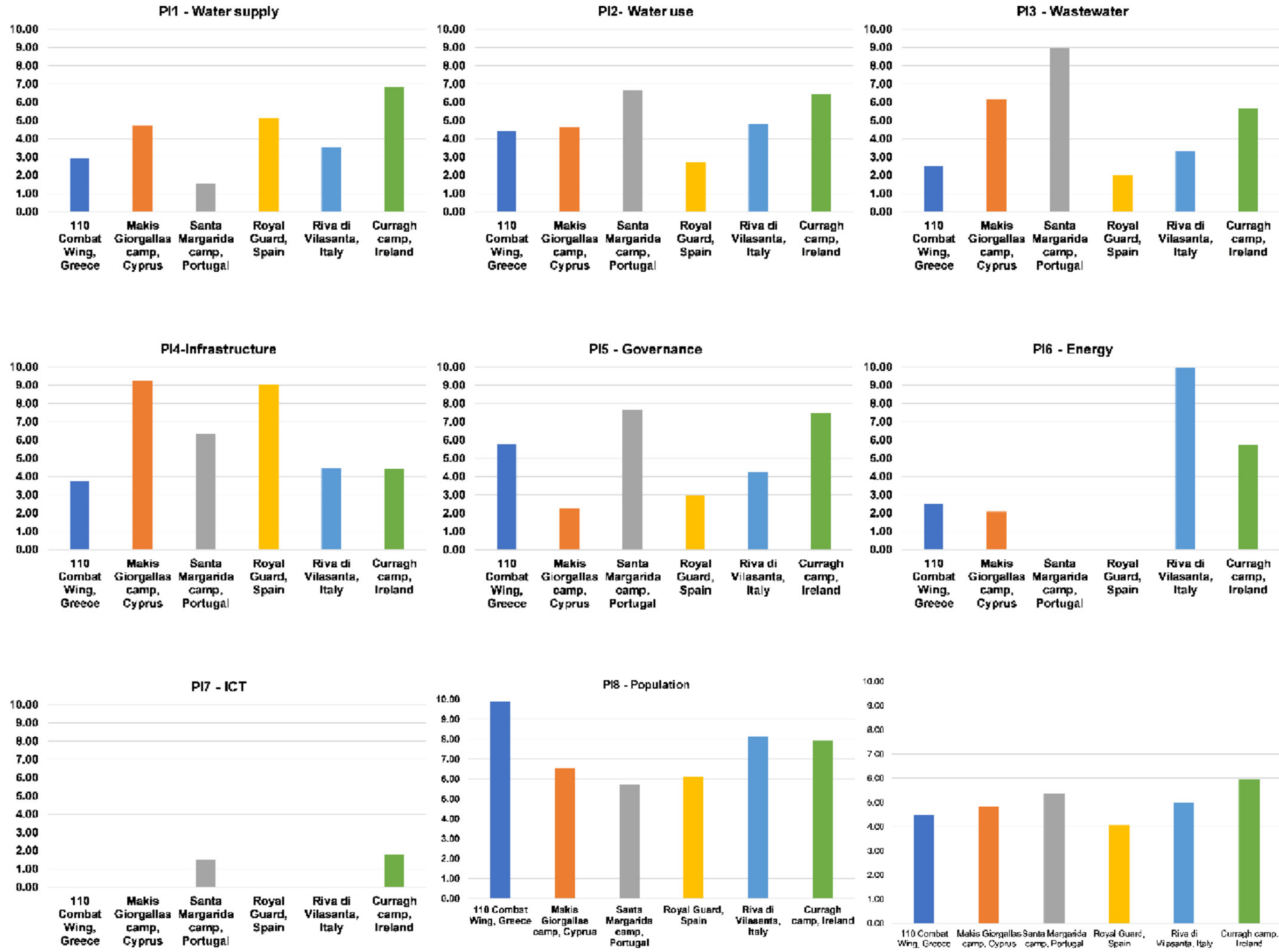

Fig. 4. Results of the assessment of each camp to the categories' Performance Indicators of the SmartBlue Camp profiling tool.

management to the camp's responsible personnel, increasing their overall awareness with respect to water and environmental management. The workshops revealed to participants several water management issues, related to the surrounding area of the camp and the management of water infrastructure, and exposed them to best practices to overcome them already in use in other military camps.

Finally, through the process of assessing the performance of each camp, opportunities for improvement were defined, based on the

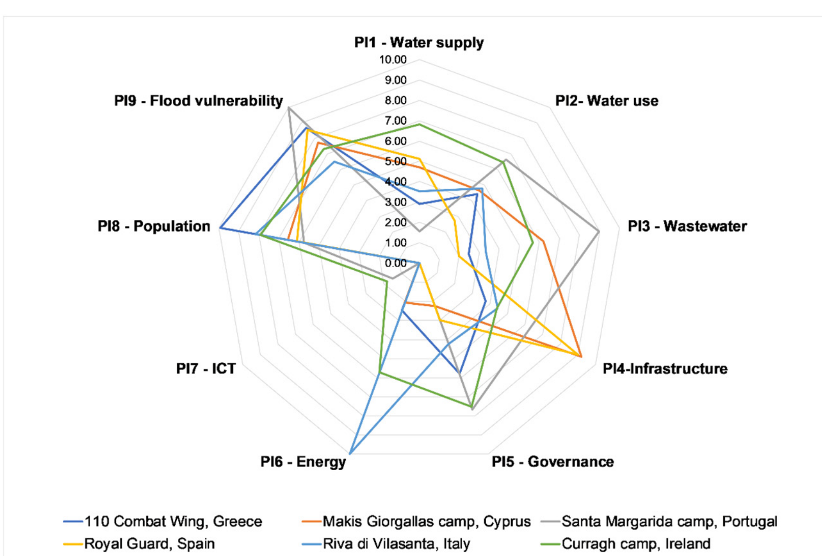

Fig. 5. Comparison of performance in the Performance Indicators' categories of the profiling tool.

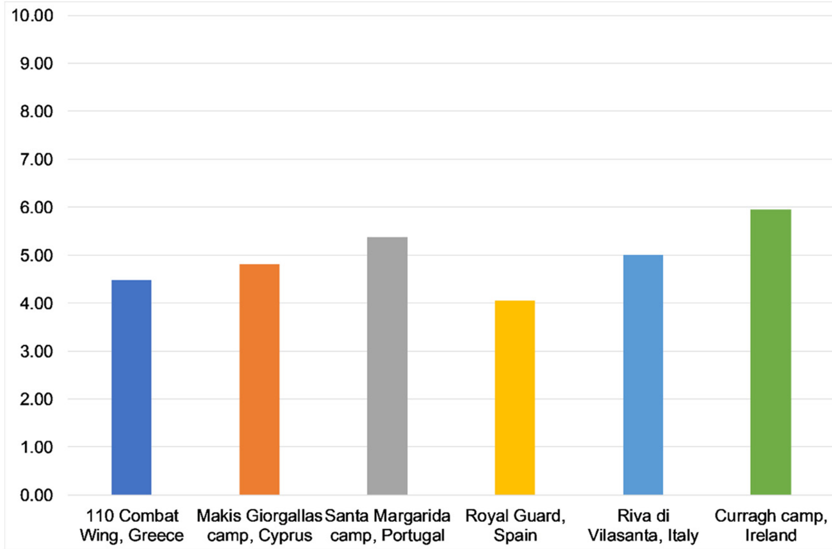

Fig. 6. SmartBlue Camp profile of all six (6) participating camps.

performance of each camp. The main proposals articulated in collaboration with project partners are presented in the next section.

110 Combat Wing, Larissa, Greece

The Context Factors assessment indicated that the greatest concern in this camp is fresh-water scarcity. Furthermore, the KPI assessment indicated that the Larissa airbase scores low on the 'water system leakages' metric. Therefore, solutions for network management and maintenance to improve efficiency, effectiveness and sustainability of the water supply network are required. It was suggested that the mapping of the topology of the network and the identification of leakages can be supported by ground penetrating radars. After having the leakages identified and before repairing them, pressure controlling devices should be installed in the network. This will prevent any pressure surges, which may occur because of the reduction of losses (>75% of total supply) causing unintended consequences while repairing the network.

Makis Giorgallas military camp, Mathiatis, Nicosia, Cyprus

The Context Factors assessment indicated that water scarcity is the greater concern of this camp. Rainwater harvesting could be employed to provide water for washing the armoured vehicles. It is estimated that if rainwater harvesting is employed at washing locations an amount of 3.824 m^3 per year could be supplied by rainwater. This is 63% of the amount of water used annually for washing armoured vehicles. Another intervention that should be taken into consideration is the installation of smart technologies and network efficiency devices. The latter includes the installation of pressure reducing valves (PRV) to control the pressure of the camp water supply network. Furthermore, flow meters should be installed to monitor critical network locations and help in the quantification and location of leakages as well as with a better understanding of water consumption.

Santa Margarida military camp, Costancia, Ribatejo, Portugal

The Context Factor assessment indicated that the greatest concern is water quality and water scarcity. KPI assessment indicated that Santa Margarida camp scores very low on ICT infrastructure while there are already in place many technologies for water reuse and aquifer recharge. Therefore, the recommended intervention involves a smart water grid system that integrates information and communications technologies (ICT) into the management of the water system. Additionally, the Santa Margarida camp implements an Environmental System that would benefit from monitoring of water flows. The installation of a series of flow sensors in the network and a water level/quality sensor in the aquifer close to the 4 boreholes is suggested.

Prince royal guard & regiment, Prince Quarter, Madrid, Spain

The Context Factors assessment of the Royal Guard Quarter camp indicated that the greatest concern in this camp is flood risk. Furthermore, KPI assessment indicated that the Royal Guard Quarter scores relatively low on the water and wastewater management metrics. A rainwater harvesting scheme, that would supply water for toilet flushing in the barracks and administration buildings, while decreasing flood risk from lateral flows was suggested as an intervention for this camp. The annual water demand that can be covered with rainwater was estimated to 8711.8 m^3.

Riva di Villasanta barracks, Cagliari, Sardinia, Italy

The Context Factor assessment of the Villasanta camp indicated that the greatest concerns in this camp are water scarcity and heat risk. KPI assessment indicated that the Villasanta camp scores relatively low on the wastewater reuse and green and blue areas metrics. Therefore, solutions involving waste water recycling and irrigation of green areas were suggested. The installation of a sewer-mining recycling scheme (Makropoulos et al., 2017) would allow the reduction of potable water demand (as part of it is now used for irrigation). This is desirable as the cost of water provided by the municipality is very high. The water obtained by this unit is going to be used for irrigating the green area of the camp and for toilet flushing. The total amount of recycled water that is going to be used in these two demands is 72.5 m^3/d.

Defence forces training centre, Curragh Camp, Co Kildaire, Ireland

The Context Factors assessment of the Curragh camp indicated that the greatest concerns in this camp are water quality and quantity. Furthermore, KPI assessment indicated that the Curragh camp scores relatively low on the infrastructure category. Therefore, solutions involving decentralized options, like rainwater harvesting and greywater recycling, should be employed to improve the sustainability of the camp. Rainwater harvesting could be installed to a building serving as a garage where vehicles could be washed with rainwater. Grey-water recycling could be installed between two barracks hosting 154 persons. The former can supply 4 m^3/d whereas the latter 7.4 m^3/d.

6. Conclusions

This work introduced the SmartBlue Camp profiling tool that has been developed to assess the sustainability of water management in military camps using a KPI framework tailored to management practices and specifics of the military sector. The framework was refined as a result of a series of workshops with relevant stakeholders and experts from the environmental and military domains. The tool allows to quickly identify strengths and weaknesses with respect to water management at the camp level, to identify opportunities for improvement and to prioritise relevant interventions. A key benefit from the tool's implementation comes from knowledge exchange and transfer between military personnel from different camps and the team undertaking the assessment. Using the framework, military camps can compare their water management practices with other camps, of similar operations and/or contextual characteristics, and take part in an structured and targeted exchange of knowledge and best practices supporting knowledge co-creation. The process also helps the sector to become aware and take advantage of past and on-going commercially available technologies (CATs), tools and research insights from the civilian sector regarding distributed water-aware technologies (Makropoulos, 2014) to (i) increase water system efficiency (e.g., leakage detection, pressure management) (ii) reduce demand (e.g., low water consuming appliances, behavioural shifts) and (iii) increase supply through alternative sources, such as re-used water (e.g., rainwater harvesting, grey-water reuse, treated waste water reuse). It is suggested that such improvements in the military water cycle are important, not only in view of the commitment of the European Armed Forces to sustainability, but also as a key enabling factor for improved resilience of operations in water scarce settings.

Acknowledgements

This work has been supported by the Smart Blue Water Camps project with funding coming from the European Defence Agency and the Hellenic Ministry of Defence.

Appendix A. Performance Indicators' equations

$$Ind1.1 = 10 - \frac{\frac{1000 * Total\ annual\ water\ supply\ of\ the\ camp\ \left(\frac{m^3}{year}\right)}{365 * Total\ population\ of\ the\ military\ camp\ (Person)} - 333 litres/person/day}{(755-333) litres/person/day} \times 10 \qquad \text{Eq. (1)}$$

$$Ind1.2 = \frac{\text{Total water selfsupply of the military camp } \left(\frac{m^3}{year}\right)}{\text{Total water supply of the military camp } \left(\frac{m^3}{year}\right)} \times 10 \qquad \text{Eq. (2)}$$

$$Ind2.1 = 10 - \frac{\frac{1000 * Total\ annual\ water\ use\ of\ the\ camp \left(\frac{m^3}{year}\right)}{365 * Total\ population\ of\ the\ military\ camp\ (person)} - 333 litres/person/day}{755-333 litres/person/day} \times 10 \qquad \text{Eq. (3)}$$

$$Ind2.2 = \frac{1 - \frac{\text{Total potable water use of the military camp } (m^3)}{\text{Total water use military operations of the military camp } (m^3)}}{1-0.73} \times 10 \qquad \text{Eq. (4)}$$

$$Ind2.3 = \frac{0.724 - \frac{\text{Total irrigation water use of the military camp } \left(\frac{m^3}{year}\right)}{\text{Total irrigated area of the camp } (m^2)}}{0.724-0.171\ m^3/m^2/year} \times 10 \qquad \text{Eq. (5)}$$

$$Ind2.4 = \frac{1 - \frac{\text{Total military operations' potable water use of the military camp } (m^3)}{\text{Total military operations' water use of the military camp } (m^3)}}{1-0} \times 10 \qquad \text{Eq. (6)}$$

$$Ind3.1a = \frac{\text{Total reused water } (m^3)}{\text{Total treated effluent and discharged } (m^3)} \times 10 \qquad \text{Eq. (7)}$$

$$Ind3.1b = \frac{\text{Total reused water } (m^3)}{\text{Total water supplied } (m^3)} \times 10 \qquad \text{Eq. (8)}$$

$$Ind3.1c = \frac{\text{Total reused water} + \text{Total recycled } (m^3)}{\text{Total water used } (m^3)} \times 10 \qquad \text{Eq. (9)}$$

$$Ind3.2 = \frac{\text{Military operations' treated wastewater } (m^3)}{\text{Total military operations' water use } (m^3)} \times 10 \qquad \text{Eq. (10)}$$

$$Ind3.3a = \frac{\text{Total population connected to secondary wastewater treatment (\#people)}}{\text{Total population of the military camp (\#people)}} \times 10 \qquad \text{Eq. (11)}$$

$$Ind3.3b = \frac{\text{Total population connected to tertiary wastewater treatment (\#people)}}{\text{Total population of the military camp (\#people)}} \times 10 \qquad \text{Eq. (12)}$$

$$Ind3.4 = \frac{\text{Sludge thermally processed (g)}}{\text{Total seweage sludge (g)}} \times 10 \qquad \text{Eq. (13)}$$

$$Ind4.1 = 10 - \frac{\text{Total water returned before use (leakage losses) } (m^3)}{\text{Total water supplied } (m^3)} \times 10 \qquad \text{Eq. (14)}$$

$$Ind4.2a = \frac{60\ years - Age\ of\ sewers\ (years)}{60\ years - 10\ years} \times 10 \qquad \text{Eq. (15)}$$

$$Ind4.2b = \frac{60\ years - Age\ of\ water\ supply\ pipes\ (years)}{60\ years - 10\ years} \times 10 \qquad \text{Eq. (16)}$$

$$Ind4.3 = \frac{\text{Total length of separated sanitary sewers and stormwater sewers (m)}}{\text{Total length sewers (incl.combined) (m)}} \times 10 \qquad \text{Eq. (17)}$$

$$Ind4.4 = \frac{\text{Total blue areas and total green areas } (m^2)}{\text{Total camp area } (m^2)} \times 10 \qquad \text{Eq. (18)}$$

Appendix A (*continued*)

$$Ind5.2 = 10 - \frac{0.5\% - \frac{\text{Total staff dedicated to water management (\#of people)}}{\text{Total staff (\#of people)}}}{0.5\% - 0\%} \times 10 \qquad \text{Eq. (19)}$$

$$Ind6.1 = \frac{4 - \frac{\text{Total energy consumed } \left(\frac{kWh}{year}\right)}{\text{Total water supplied } (m^3)}}{(4-0)\frac{kWh}{m^3}} \times 10 \qquad \text{Eq. (20)}$$

$$Ind6.2 = \frac{\text{Total volume of wastewater treated with techniques to recover energy } (m^3)}{\text{Total volume of wastewater treated in wastewater treatment plants } (m^3)} \times 10 \qquad \text{Eq. (21)}$$

$$Ind6.3 = \frac{\text{Total renewable energy generated (kWh)}}{\text{Total energy consumed (kWh)}} \times 10 \qquad \text{Eq. (22)}$$

$$Ind8.1 = \frac{30\% - Absolute \text{ personnel variation during the last ten years } (\%)}{30\% - 10\%}\ x\, 10 \qquad \text{Eq. (23)}$$

$$Ind8.2 = 10 - \frac{\text{Maximum monthly number} - \text{Minimum monthly number}}{\text{Minimum monthly number}} \times 10 \qquad \text{Eq. (24)}$$

$$Ind8.3 = \frac{\text{Total number of personnel}}{\text{Total number of permanent staff}} \times 10 \qquad \text{Eq. (25)}$$

$$Ind9.1 = 10 - \frac{\text{Area of the camp that would flood with 1 meter river level rise } (m^2)}{\text{Total camp area } (m^2)} \times 10 \qquad \text{Eq. (26)}$$

$$Ind9.2 = 10 - \frac{\text{Area of the camp that would flood with 1 meter sea level rise } (m^2)}{\text{Total camp area } (m^2)} \times 10 \qquad \text{Eq. (27)}$$

$$Ind9.3 = 10 - \frac{\text{Total impervious area } (m^2)}{\text{Total camp area } (m^2)} \times 10 \qquad \text{Eq. (28)}$$

Appendix B. Data required for the implementation of the SmartBlue Camp profiling tool

Data for Context Factors	Units
Annual abstracted freshwater (RBD)	m^3/year
Total renewable resource (RBD)	m^3/year
Annual abstracted groundwater (RBD)	m^3/year
Annual available recharge (RBD)	m^3/year
Information about seawater intrusion and groundwater salinization (RBD)	Qualitative
WFD chemical status of surface water (average if many sources are used)	%
WFD ecological status of surface water (average if many sources are used)	%
WFD chemical status of groundwater (average if many are used)	%
Is the area surrounding the camp under flood risk?	Yes/no
What is the percentage that would flood for floods of a high return period (e.g. >500)?	%
What is the percentage that would flood for floods of a medium return period (e.g. >50)?	%
What is the percentage that would flood for floods of a low return period (e.g. <50)?	%
Number of tropical nights (>20 °C) and hot days (>35 °C) in the period 2071–2100	# of days
General government expenditure for military defence	%
Personnel budget	%
Intermediate consumption	%
Capital investment	%
Country policies to satisfy camps' requests relevant to water and wastewater	Qualitative
Population change during the last ten years	%
Military population change during the last ten years	%
Adaptation to climate change	Qualitative
Water demand and efficiency management	Qualitative
Flood risk management	Qualitative
ICT factors	Qualitative

Data for Performance Indicators	Units
Total water supply of the military camp	m^3/year
Total population of the military camp	# of people
Total self-abstraction of the military camp	m^3/year
Total public supply of the military camp	m^3/year
Total use of the military camp	m^3/year
Total water use for non-military operation of the military camp	m^3/year
Total potable water use of the military camp	m^3/year
Total potable water use in residential buildings for permanent staff	m^3/year
Total potable water use in residential buildings for non-permanent staff	m^3/year
Total potable water use in administration buildings	m^3/year
Total irrigated area of the military camp	m^2
Total irrigation water use of the military camp	m^3/year
Total military operations' water use of the military camp	m^3/year
Total military operations' non-potable water use of the military camp	m^3/year
Total military operations' potable water use of the military camp	m^3/year
Total treated effluent and discharged	m^3/year
Total reused water	m^3/year
Total locally recycled water	m^3/year
Total population connected to secondary wastewater treatment	# of people
Total population connected to tertiary wastewater treatment	# of people

Appendix B (*continued*)

Data for Performance Indicators	Units
Total sewage sludge	g/year
Dry weight of sludge thermally processed	g/year
Dry weight of sludge disposed in agriculture	g/year
Military operations' treated wastewater	m^3/year
Total area	m^2
Total green area	m^2
Total blue area	m^2
Total water returned before use (leakage losses)	m^3/year
Average age of sewers	Years
Average age of water supply pipes	Years
Total length of sanitary sewers	km
Total length of combined sewers	km
Total length of storm water sewers	km
Total staff	# of people
Total staff dedicated water resources and water infrastructures	# of people
Total energy consumed	kWh/year
Total energy consumed from water related infrastructure	kWh/year
Total volume of wastewater treated in wastewater treatment plants	m^3/year
Total volume of wastewater treated with techniques to recover energy	m^3/year
Renewable energy generated	kWh/year
ICT for water management	Qualitative
ICT for wastewater management	Qualitative
Personnel change during the last ten years	%
Minimum monthly number of people in camp	# of people
Maximum monthly number of people in camp	# of people
Total number of personnel	# of people
Total number of permanent staff	# of people
Area of the camp that would flood with 1-meter river level rise	m^2
Area of the camp that would flood with 1-meter sea level rise	m^2
Total impervious area	m^2

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